Marshall Space Flight Center

FY 2002 Annual Report

Statement of the Director

The Marshall Space Flight Center is pleased to present its 2002 Annual Report. This report is an overview of the Marshall Center's demonstrated successes and outstanding service and commitment to America's space program.

The year 2002 was exciting, as the Marshall Center pushed forward to support the Agency's new Vision and Mission. In April, NASA Administrator Sean O'Keefe introduced the Agency's new Vision and Mission statements. They are simple, yet powerful, and provide a beacon for us to follow. The Marshall Center quickly adopted and integrated these statements into our culture: *To improve life here, To extend life to there, To find life beyond; and To understand and protect our home planet, To explore the Universe and search for life, To inspire the next generation of explorers…as only NASA can.*

In addition to the new Vision and Mission statements, our work ethic was guided by our commitment to the Marshall Values. The Values serve as the guideposts by which we do business. Marshall places top priority in people, customers, excellence, teamwork, and innovation. The MSFC Mission is "To enable, through our values-based culture, the unbounded access to and use of space to benefit humanity." Concurrently, Marshall's priorities were guided by our commitment to safety. This commitment was set many years ago, and MSFC continues to work diligently to ensure the safety of the public, workforce, and property.

The Marshall Center continued its dedication to our three mission areas: Space Transportation Systems Development, Microgravity, and Space Optics Manufacturing. In April, Space Shuttle *Atlantis* carried another Marshall success story into orbit, flying three new Block II Main Engines during STS–110. The enhanced engines, which incorporate an improved high-pressure fuel turbopump with a stronger integral shaft/disk and tougher bearings, increase flight safety and reliability, potentially increasing the number of Shuttle launches between overhauls. The Space Launch Initiative, spearheaded for NASA by the Marshall Center, reached a number of critical goals in 2002, determining the Agency's path to develop an Orbital Space Plane for crew transfer and crew rescue, and to develop Next Generation Launch Technology (NGLT) initiatives. As part of the NGLT program, the Marshall Center will continue to develop advanced launch vehicles, chemical propulsion engines, and ambitious new hypersonic flight technologies as a joint effort with the U.S. Department of Defense to meet key next-generation launch technology goals. The Microgravity Science Glovebox, built and managed at Marshall, went in to service aboard the Space Station, enabling the Station crew to safely perform experiments involving fluids, flames, particles, and fumes. Marshall also continued to successfully manage round-the-clock science research aboard the Station at its Payload Operations Center. The Chandra X-ray Observatory also continued to make unprecedented scientific observations throughout 2002. The Marshall-managed observatory spotted unique anomalies in ancient galaxies, gleaned new information about black holes, and discovered a pair of stars, one too small and one too cold, that challenge our understanding of nuclear physics and the very nature of matter itself. The Marshall Center is also partnering with Goddard Space Flight Center on two new space optics programs: the James Webb Space Telescope and the Constellation-X Space Telescope, the successors, respectively, to the Hubble Space Telescope and Chandra itself.

Other highlights of 2002 included: the groundbreaking ceremony for the new Propulsion Research Laboratory, a 66,000 square feet facility that will perform landmark propulsion research; the launch of a new Web site dedicated to the Marshall Center's diverse workforce; the Center's designation as a historic aerospace site by the American Institute of Aeronautics and Astronautics; and the commemoration of the 30th anniversary of Apollo 17, complete with a visit by the last two astronauts to walk the lunar surface, Gene Cernan and Harrison Schmitt.

I am pleased with the incredible accomplishments and highlights of 2002. Our success is because of the dedication of our outstanding workforce. I know that 2003 will be another exciting year.

A.G. Stephenson
Director


NASA
NASA/MSFC Vision
To improve life here,
To extend life to there,
To find life beyond.
NASA´s Mission
To understand and protect our home planet,
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Marshall Values

The Marshall Space Flight Center team is committed to these core values.

People:

- **We** recognize that the people who work here are "most important"—and are our greatest strength.
- **We** create a safe and healthy environment.
- **We** encourage balance between personal and professional life.
- **We** enable personal and professional growth.
- **We** commit ourselves to the highest standards of integrity and ethical behavior.
- **We** reward and celebrate our accomplishments.
- **We** recognize individual and cultural differences and treat each other with dignity and respect.

Customers:

- **We** are accountable to our customers and are committed to their satisfaction.
- **Our** customers can depend on us to deliver quality products and services.

Excellence:

- **We** pursue excellence in our people and in everything we do.
- **We** promote continual learning and improvement.
- **We** hold one another accountable for doing what we commit to do.

Teamwork:

- **We** are a unified and interdependent team.
- **We** cooperate, communicate openly, and share ideas with each other for the common good.
- **We** seek and enable partnerships with other NASA Centers, other agencies, academia, industry, and our local and global communities.

Innovation:

- **We** promote innovation and creativity.
- **We** seek different ideas and perspectives.
- **We** are committed to making a significant difference.
- **We** are willing to accept well-assessed, selected risks in the pursuit of our goals—but never at the expense of safety.

These values serve as the principles that guide our decisions and behavior.

Introduction

The Marshall Space Flight Center (MSFC), a field Center of the National Aeronautics and Space Administration (NASA), was established on July 1, 1960, with the transfer of land, buildings, property, space projects, and personnel from the United States Army.

Dr. Wernher von Braun was named the Center's first director. Under von Braun's guidance, MSFC's Mercury-Redstone vehicle boosted America's first astronaut on a suborbital flight in 1961.

MSFC's first major program was the development of the Saturn rockets, the largest of which first sent man to the moon in 1969 and Skylab into orbit in 1973. Other successful projects in MSFC's history include the three High Energy Astronomy Observatories, the Hubble Space Telescope, the Chandra X-Ray Observatory, and the MSFC-developed propulsion systems which launched America's first Space Shuttle.

MSFC is involved in Space Propulsion and provides leadership in space transportation development, microgravity, and space optics manufacturing technology. MSFC is a vital resource for the development and utilization of key scientific missions that will advance the frontiers of knowledge and human exploration. Our commitment to mission success is evidenced not only by our accomplishments over the past year, but also our dedication and our focus on the future.

MSFC FY 2002 Dollars and Workforce by Benefiting State

State	FY 2002 $Millions	FY 2002 Jobs	State	FY 2002 $Millions	FY 2002 Jobs
Alabama	897	9,444	Nevada	16	189
Arizona	2	30	New Hampshire	0.3	4
California	382	4,278	New Jersey	2	20
Colorado	28	194	New Mexico	2	28
Connecticut	97	1,153	New York	5	61
D.C.	3	40	North Carolina	1	12
Delaware	1	10	Oklahoma	0.1	1
Florida	120	1,391	Ohio	13	159
Georgia	4	52	Oregon	1	7
Hawaii	0.3	3	Pennsylvania	6	68
Idaho	1	7	Rhode Island	0.2	2
Illinois	9	105	South Carolina	0.1	2
Indiana	1	13	Tennessee	5	57
Iowa	2	29	Texas	14	116
Kansas	0.2	2	Utah	314	3,744
Kentucky	6	72	Vermont	1	16
Louisiana	246	2,929	Virginia	45	533
Maine	0.1	1	Washington	7	84
Maryland	4	53	West Virginia	1	9
Massachusetts	58	696	Wisconsin	6	68
Michigan	6	72	Wyoming	0.01	0.2
Minnesota	13	155	Foreign	1	7
Mississippi	2	18	Puerto Rico	1	7
Missouri	1	16	Unidentified/Misc.	115	1374
Montana	0.4	5			
			MSFC Total	**2,441**	**27,335**

Safety and Mission Assurance

The Marshall Space Flight Center (MSFC) and the Safety and Mission Assurance (S&MA) Office have made significant progress regarding commitment to safety and mission success. The S&MA goal is to help establish NASA as a world leader in safety. MSFC continually strives to prevent human injury and occupational illnesses and ensure the safety of all operations and products. S&MA is dedicated to the principle that mission success starts with safety, and this objective includes protecting the public, astronauts and pilots, the NASA workforce, and high-value equipment and property. This approach, in which safety permeates every aspect of our work, is a major influence in our commitment to mission success. It can be noted that the S&MA team is an intricate partner in every project and activity at MSFC, and will continue with these efforts.

The S&MA Office recognizes that the people of MSFC are our greatest strength. The disciplines within the S&MA Office have been strengthened by recruiting, training, and mentoring new employees. New S&MA employees have been recruited through Balancing the Marshall Workforce activities. A formal S&MA Rotational Development Program, aimed at allowing other Center employees to gain S&MA experience, was initiated, and resulted in six employees from other MSFC Directorates working in S&MA on detail assignments. A number of innovative training programs, aimed at improving the skills of the available workforce, were deployed. The personal and professional growth of its employees is promoted by S&MA by implementing a successful internal mentoring program.

S&MA creates, coordinates, and facilitates MSFC safety initiatives to help assure a safe and healthy workforce. During FY 2002, the Safety, Health, and Environmental (SHE) Committee was restructured to significantly increase employee involvement in the decision making process. The Center decided not to pursue Voluntary Protection Program Star certification as an explicit goal, but rather to continue aggressively improving our SHE Program with a focus on the safety and health of our workforce. In addition, S&MA increased its community outreach efforts by participating in a Lowes Home Improvement Center safety weekend, delivering a safety presentation at Alabama A&M University, and conducting workshops at the MSFC Family Fun Day and Take our Children to Work Day.

With the ISO 9001:2000 emphasis on Customer Satisfaction and Continual Improvement (CS/CI), the S&MA Office formalized a process for seeking and documenting customer feedback through quarterly CS/CI reviews. Because of its unique mission, S&MA is committed to the ideal of balancing its independent assessment role with customer needs. S&MA led a series of process audits to significantly refine processes at a number of MSFC contractor facilities. These led to improvements in the efficiency of Shuttle manufacturing while continuing to assure flight safety. Through participation in the MSFC Design/Manufacturing Continuous Improvement Team, S&MA sought to impact in-house projects in a similar fashion. An environment has been created within S&MA that capitalizes on individual and cultural differences to add value to our products and services. This is reflected in employee and customer surveys, which indicate that diversity is one of S&MA's strongest assets.

S&MA seeks and enables partnerships with other NASA Centers, other agencies, academia, and industry, as well as the local and global communities. A team of civil service and contractor discipline experts was led by S&MA in an Agencywide effort to refine Process Quality Assurance Requirements for core S&MA processes. S&MA is actively involved with a variety of NASA-wide working groups, such as the Process-based Mission Assurance Team, Lessons Learned Information Systems Management Team, NASA Nondestructive Evaluation Working Group, NASA Quality Leadership Forum, Agency Risk Management Colloquium, and others. Personnel in the S&MA Office routinely coordinate technical interchange meetings for MSFC projects and are active in interagency teams, such as the Government-Industry Data Exchange Program and the NASA/U.S. Army Missile Command Reliability Working Group.

S&MA has developed a number of new Web-based tools, and continued to enhance existing products, such as the Supervisor's Safety Web Page, Inventory of Hazardous Operations, the "It Could Happen to You" database, and others, to provide tools that will increase the safety of personnel at MSFC. S&MA developed a detailed proposal to NASA Headquarters for the development of a Web-based tool to automatically generate S&MA Plans for programs and projects. The Center's safety performance has improved over previous years, indicating the steady progress toward realizing an MSFC culture that embraces safety.

NASA continues to increase the reliability and safety of Shuttle flights through a series of enhancements to the Space Shuttle Main Engines.

Metrics

FY 2002 Safety and Mission Success Metrics

Achieve a world-class lost-time injury rate of 0.10 or less, with an ultimate goal of 0.

The FY 2002 combined civil service and contractor lost-time injury rate (LTIR) of 0.17 did not meet the Center's goal of 0.10 or less. However, the FY 2002 LTIR is the lowest recorded LTIR to date for the Center, indicating a positive trend toward attaining the stated goal.

Zero type A or B mishaps in FY 2002.

MSFC experienced no type A or B mishaps for FY 2002.

Maintain a mission success rate of 100 percent.

All 19 payload/cargo elements launched by MSFC during FY 2002 met their mission success criteria.

All MSFC projects will complete safety reviews on time.

MSFC payload and cargo elements conducted zero in-house Payload Safety Readiness Review Boards for FY 2002. In addition, payload and cargo elements successfully conducted 29 Johnson Space Center/Kennedy Space Center Payload Safety Reviews and all were completed on time.

FY 2002 Quality Success Metrics

Obtain full-scope, ISO 9001:2000 registration.

MSFC received full-scope registration to ISO 9001:2000 in November of 2001. The registration was an upgrade from the ISO 9001:1994 revision, as well as an expansion in the scope of the registration to include all activities performed at MSFC versus only flight hardware activities. The scope includes all products and services provided by MSFC. MSFC supports the NASA Agency infrastructure and is a major contributor to all its scientific and technical enterprises. One additional external audit was performed in FY 2002, resulting in continuation of the ISO registration.

S&MA facilitated the development of a proactive ergonomics program at MSFC. The program addresses funding, procurement of new furniture, development of ergonomics training courses, and a draft MSFC Procedures and Guidelines document, which reflects the most current Occupational Safety and Health Administration ergonomic policy.

S&MA began investigating the principles of a behavioral-based safety program. The focus is on training employees to embrace safety so that it becomes second nature to them in all aspects of their lives, rather than placing the emphasis on the development and enforcement of rules and regulations solely within the workplace. The S&MA Office safety communications venues, such as the MSFC Safety Bulletins, emphasize personal responsibility and the importance of personal hazard awareness in assuring the safety of personnel and hardware. Employees are encouraged to share information about incidents that occur during off-duty hours or to family members. Cultural change is also evident in the increased discussion of off-duty experiences during the Safety Moments session of the Center Staff Meetings this year.

Space Transportation Systems Development

MSFC manages development, implementation, and advocacy of advanced Earth-to-orbit and in-space propulsion systems and technologies that are critical to enabling a new generation of space missions. The MSFC's overriding emphases are on safety, reliability, and a high return on investments in terms of scientific, commercial, and overall mission value—thereby enhancing U.S. industrial growth, preserving its leadership role in space, and improving the quality of life on Earth.

It is the responsibility of MSFC to maintain and continuously improve the skilled personnel, processes, facilities, and support factors needed to accomplish these goals. MSFC also supplies crosscutting support to all related NASA enterprises and to all its partners and allies, including other NASA field Centers, industry, academia, and Government organizations.

The Space Shuttle Projects Office

When NASA's Space Shuttle lifts off the ground, it does so with the help of two Solid Rocket Boosters (SRBs) and three reusable, high-performance Main Engines (SSMEs) fed by a propellant-filled External Tank (ET). Those elements—the SSMEs, ET, Reusable Solid Rocket Motors (RSRMs), and SRBs—are managed at MSFC's Space Shuttle Projects Office (SSPO). The SSPO works closely with five prime contractors—Rocketdyne Propulsion and Power of The Boeing Company; Pratt & Whitney, a United Technologies Company; Lockheed Martin Space Systems—Michoud Operations; ATK Thiokol Propulsion, an Alliant Techsystems Inc., company; and United Space Alliance (USA)—to build and operate the components.

During FY 2002, NASA flew four Space Shuttle missions, servicing the Hubble Space Telescope, delivering crews and supplies to the *International Space Station* (*ISS*) and installing the S-Zero Truss—the backbone for future expansion—to the *ISS*. Shuttle crews also enhanced the capabilities of the *ISS* robotic arm by installing the Mobile Base System and devoted time to dozens of science experiments. MSFC propulsion elements successfully supported these flights, with only one in-flight anomaly (IFA). FY 2002 also saw the advancement of numerous SSPO initiatives to improve the safety, reliability, and maintainability of the Shuttle's SSMEs, ET, RSRMs, and SRBs.

Space Shuttle Main Engine

Block II Engine

MSFC continues to increase the safety and reliability of Space Shuttle flights through enhancements to its elements. During FY 2002, the SSPO SSME Project Office completed integration of the Block II engines into the Shuttle fleet. Block II combines the new high-pressure fuel turbopump (HPFTP) with the previously flown redesigned high-pressure oxidizer turbopump. STS–110 in April 2002 marked the first flight of a cluster of three Block II SSMEs. All shuttle flights are now powered by Block II SSMEs. The Block II configuration improves the engines' reliability by 28 percent over Block IIA, and is expected to increase the life of the engines and reduce maintenance and overhaul costs. Part of the new design incorporated new engine manufacturing techniques that slashed 469 welds

from the HPFTP and cut all flow-path sheet metal shielding. An improved turbopump bearing design eliminated wear issues and increased the load capability for the rotor support system, thus reducing synchronous vibrations by a factor of two to four. The single-piece rotor and disk, along with robust bearings, result in a turbopump that is more tolerant to wear.

Advanced Health Management System

The SSME Project Office also continues its work on the engine's Advanced Health Management System (AHMS), a high-tech system that couples vibration sensors and advanced digital signal processing with upgraded computing technology. The first phase of this enhancement will improve the engines' computers, called controllers, enabling them to safely shut down an engine when excessive vibrations are detected in the high-pressure turbopumps. Once implemented, Phase I is expected to reduce the risk of engine failure by 23 percent. During FY 2002, three new AHMS circuit card designs were successfully fabricated, assembled, and integrated into two flight configuration controllers. The first of these units is to begin qualification testing in FY 2003, and the second will be used for engine hot-fire certification testing at NASA's Stennis Space Center. The project remains on schedule to support the first flight of Phase I in June 2004.

The SSME Project also completed development of the AHMS Phase I digital computer unit flight software in FY 2002. A rigorous verification and validation effort on this software began in August and will continue through FY 2003. The first four flight SSME controllers to receive the AHMS upgrade have been removed from fleet service and are being retrofitted.

External Tank

Friction Stir Welding

During 2002, the ET Project Office began implementation of a revolutionary welding process—friction stir welding (FSW)—that enhances the strength and quality of the ET's welded joints. FSW is a solid-state welding process that joins two components through frictional forces combined with forging pressures. Since existing ET welding tools could not be readily adapted, new tools were designed and built to allow for the structural loads associated with FSW. These tools are being used to weld the longitudinal barrel welds for both the ET hydrogen and oxygen tanks. The first tool was activated in late October and is currently welding ET flight hardware.

The welds made with FSW are virtually defect-free and approximately 48 percent stronger than fusion welds. The result is a safer, more reliable welded joint for the ET. The FSW project is a major success for the SSPO because it has achieved all of its technical objectives, schedule projections, and cost targets.

Lean/Six Sigma and Build Process Teams

In 2002, the ET project continued its aggressive plan to implement Lean/Six Sigma and Build Process Teams (BPT) in ET manufacturing at Michoud Assembly Facility (MAF). Lean/Six Sigma focuses on reducing/eliminating defects and removing process variability, thus making the process more predictable and improving overall quality of the product. Thirty-six BPTs have been established and consist of technicians, inspectors, supervisors, and essential technical personnel. Each team is charted to improve quality, safety, cost, and schedule performance within the team. One hundred percent of the operations personnel are engaged in the BPTs, with additional external personnel supporting this effort as required.

Lean/Six Sigma initiatives are delivering programmatic benefits with between 11 and 13 percent cumulative labor hour reductions. Lean/Six Sigma improvements, combined with BPT initiatives, resulted in an average of 13,000 fewer build hours for the last four tanks in the Fifth Buy Production Contract, which ended in September 2002.

MAF Environmental Management

The MAF Environmental Management program continues to demonstrate sustained outstanding environmental compliance and operations. Unannounced regulatory agency inspections of the facility's Hazardous Waste Management and Clean Air Act Compliance programs resulted in no violations or concerns.

MAF's pollution prevention and waste reduction programs have yielded a 93 percent reduction—from Environmental Protection Agency (EPA)'s 1988 baseline—in air emissions and offsite disposal of the EPA targeted chemicals. In addition, the generation of hazardous waste has decreased 38 percent since 1995. MAF has received four Governor's Awards for Environmental Leadership over the last five years, including this year's award for implementing a materials recovery program that has recycled over two million pounds of nonhazardous waste since 2000.

Solid Rocket Booster

Bolt Strength Requirements Change

The SRB Project Office continues to maintain the safety and integrity of the Space Shuttle by managing a diverse array of technologies, including structures, avionics, thrust vector control, range safety, parachutes and recovery, rocket motors, and robotics. Another such discipline is pyrotechnics, or the science of controlled explosions. About two minutes into the Space Shuttle's flight, explosive bolts are used to separate the SRBs from the orbiter and ET. The SRB is

attached to the ET by a single forward bolt and by three aft attach struts, which also contain explosive separation bolts. During FY 2002, the SRB Project calculated that reducing the strength of the bolts on the three aft attach struts would increase the efficiency of the explosive charge. This improvement to the bolts will reduce the separation risk, resulting in a 27 percent decrease in SRB mission risk. This upgrade will also cut time spent building and testing the bolts, providing schedule improvements and cost savings.

SRB Integrated Electronic Assembly Supportability Upgrade

In 2002, the SRB Project also initiated an effort to upgrade the SRB integrated electronics assembly (IEA). Each booster has two IEAs—200-lb "black boxes" that serve as a conduit between the orbiter and the boosters. The IEAs distribute power, provide data transmission, and route command signals. Critical IEA functions include operating the SRBs' thrust vector control system, separating the SRBs from the shuttle vehicle, and initiating the recovery sequence, including deploying the parachute.

Originally designed in the 1970s with a design life of 10 years, the IEAs were qualified for 20 flights: today, the average IEA is 18 years old and has flown 11 times. During flight, the IEAs are subjected to rigorous in-flight vibration, an impact shock when the boosters land in the ocean at 60 mph, and then exposure to salt water during the 24- to 48-hour booster recovery operation. Because the operating environment is harsh, reuse of the IEAs has led to an increase in certification test failures on the IEA wiring harness assemblies. The harness assemblies are comprised of more than 2,000 individual wires that, if laid end to end, would stretch almost a mile in length. An improved wiring harness design will increase the assemblies' ability to withstand the harsh flight and recovery environments, thus increasing reliability and reducing requirements for repair and maintenance.

Largest Kennedy Space Center Hazardous Waste Eliminated

During FY 2002, the SRB Project made tremendous strides to eliminate hazardous waste at Kennedy Space Center (KSC). During the year, the project changed to a more environmentally friendly chemical primer, alodine, which eliminates the toxic metal contained in its predecessor. This replacement virtually eliminates the hazard: alodine rinse water constitutes 25 percent of the overall USA-Florida waste and more than 40 percent of the SRB element waste. The achieved reduction exceeds the goal set by USA and the federal government. The replacement also reduces the risk to employees and the risk of fire hazards, decreases liability associated with environmental contamination, and eliminates regulatory burdens on tank certification, compliance inspections, and environmental reporting.

SRB Retrieval Operations Safer

The SRB Project requested and received funding during FY 2002 from Shuttle Program Industrial Engineering for Safety to incorporate safety upgrades for the two SRB retrieval ships and diver equipment. In one upgrade, a NITROX system was installed that allows more oxygen in the air that the divers breathe, thus decreasing the risk of decompression illness. The pneumatically operated enhanced diver-operated plug (EDOP), which increases diver safety during underwater operations, was also upgraded. During retrieval, the EDOP is used to install a plug in the SRB nozzle, which is 100 feet under the water during the installation. Once the plug is in place, air is pumped into the SRB, moving it from a vertical position to a horizontal position that makes towing to KSC easier. In addition to these enhancements, state-of-the-art dive equipment was purchased and several safety modifications were incorporated on both ships.

Reusable Solid Rocket Motor

ATK Thiokol Safety

The importance of safety continues to be a principal focus in the manufacture of the Space Shuttle's RSRM. During the past year, RSRM's prime contractor, ATK Thiokol Propulsion in Promontory, UT, reached a number of significant safety milestones. The Final Assembly Work Center surpassed 2 million hours—eight years—without a lost time accident. In addition, the Quality Assurance Department completed over 1 million hours—1.3 years—without a lost time accident. Because of its low accident rates, ATK Thiokol Propulsion received the following awards in 2002:

- Occupational Hazards Magazine (November 2001 Issue) Champions of Safety award for CY 2001; and,
- Utah Labor Commission's Workplace Safety Award for Self-Insured Employer.

ATK Thiokol continues to reflect below average job-related accident rates compared to rates for similar industries.

Process Automation

During 2002, the RSRM Project Office supervised the installation of systems that will increase RSRM hardware reliability and reduce risk for personnel who work with the motors. For example, the automated eddy current inspection and grit blast processes offer great improvement for metal parts, where flaw detection is imperative and refurbishment damage must be minimized. The automated eddy current inspection system is an electronic sensor-based inspection technique that reduces reliance on human sight and judgment in identifying flaws. The project is presently using the new system to examine RSRM metal parts and comparing it with existing techniques. Implementation of the new system is planned for FY 2003. The RSRM Project is also managing the development of a robotic grit-blast system for removing paint and thermal protection system materials from the RSRMs during

refurbishment. The robotic system, which has been installed and is being programmed, will replace the use of hand-held high-pressure equipment, increasing plant safety. The robotic system will also improve consistency on rotation speed and blast pressure, reducing the chance for hardware damage.

Full-Scale RSRM Test Motors

During FY 2002, the RSRM Project completed several major milestones towards improving RSRM design robustness and addressing materials obsolescence issues. A cornerstone of these initiatives was the successful static-test of Engineering Test Motor 2. The Engineering Test Motor Project is an ongoing program that tests, in full-scale design, elements that are not ready for certification testing, or that explores fault-tolerant performance characteristics. The RSRM Project's second engineering test motor was static-tested November 1, 2001.

Major test accomplishments included:

- Successful demonstration of carbon fiber rope (CFR) as a new nozzle joint thermal barrier.
- Successful demonstration of a new, robust bolted joint design for Nozzle Joint 5, which eliminates both joint skip and plastic deformation of washers.
- Demonstration of rayon carbon cloth processing enhancements designed to eliminate the potential for throat pocketing.
- Evaluation of several rayon replacement candidates.

24-in Solid Rocket Test Motor

In the past, the modified NASA motor has been the only large subscale test vehicle for validation of material changes or design concepts before full-scale static testing available to the RSRM Project. The 24-in solid rocket test motor (SRTM) was recently developed as a low-cost test-bed for RSRM nozzle and insulator components to supplement the modified NASA motor. The SRTM typically allows engineers to gather about 90 percent of the data that would be available from a modified NASA motor, but at roughly one-third the cost. In developing the SRTM, particular care was taken in the design of the aft dome and submerged nozzle region to provide flow similarity with the full-scale RSRM aft dome environment. The result is a test-bed providing the same heating and erosion environment as a full-scale RSRM in the aft dome and nozzle entrance regions. Additionally, the SRTM is the only subscale test motor capable of being fired nozzle down to simulate slag pooling in the aft dome region. To date, static tests conducted at MSFC have supported a variety of objectives, including development of CFR for RSRM nozzle joint application, RSRM aft dome candidate insulation erosion performance, and rayon replacement project material screening.

New Thermal Barrier for RSRM Nozzle Joints

The RSRM nozzle contains five major joints where subassemblies are brought together to form the nozzle assembly. Currently, the RSRM design uses room-temperature vulcanization as a thermal barrier in these joints. However, installing room-temperature vulcanization into the nozzle joint requires significant operator skill and timing to ensure the joint is adequately backfilled. The use of CFR in development testing has proved to be a simpler and more thermally effective approach to thermal barriers in the RSRM nozzle. Following three years of development and demonstration, a new thermal barrier for Joints 2 and 5, based on CFR, is now ready for certification on Flight Support Motor–10, set for test-firing in January 2003. Implementation of the CFR thermal barrier will increase design robustness and joint performance repeatability.

Shuttle Integration Office

The Shuttle Integration Office (SIO) continued to perform the essential task of integrating several engineering, business, and project office support disciplines for the SSPO. Responsibilities include managing Shuttle Engineering Support Center (SESC) activities related to shuttle launches. SESC personnel provide SSPO engineers and management with real-time launch preparation and ascent data, processed by computer systems linked to KSC and configured for SSPO use by the SIO. Launch data is also downloaded and provided to the SSPO community for analysis. During FY 2002, the SESC team supported four launches and five launch simulations. Another SIO responsibility is the Shuttle Environmental Assurance (SEA) Initiative. This team, which includes members from the entire Space Shuttle Program community, addresses environmental materials obsolescence and materials replacement issues. Major efforts in 2002 included investigating replacements for foam-blowing agents, solvents, primers, and ozone-depleting chemicals. The SIO-managed Shuttle Outreach program is designed to take the excitement of the Space Shuttle on the road to a broad range of audiences. The Outreach team visited trade shows, seminars, schools, and museums, providing students and the aerospace community with a hands-on look at MSFC's Space Shuttle role.

Metrics

FY 2002 Space Shuttle Projects Office Metrics

Space Shuttle Project Office

Conduct the following Safety Initiatives to ensure a safe workplace environment:

- *Monthly area walk-throughs and documentation.*
- *Monthly project safety meetings.*
- *Maintain safety performance records at contractor facilities that exceed industry standards.*

The SSPO conducted 12 safety walk-throughs and 12 All-Hands safety meetings for FY 2002. The walk-through results are documented and maintained by the SIO and are posted on each floor of Building 4202 where the SSPO maintains offices. No major safety findings or violations have been observed during the safety walk-throughs. Furthermore, SSPO personnel in Building 4202 reported no lost-time incidents. Safety Performance Records for Lost-Time Incident Rates at the Shuttle prime contractors for the period 10/01/01 through 9/30/02 are as follows:

- SRB - 0.17 (excluding marine operations at KSC).
- ET - 0.095.
- RSRM - 0.33.
- SSME - 0.42.

The SSPO will meet the manifest and improve mission supportability through robust processes, process control, production process efficiency, and on-time launches with no delays attributed to the MSFC propulsion elements.

The SSPO met the manifest for all four missions flown in FY 2002:

- STS–108 (12/05/01).
- STS–109 (03/01/02).
- STS–110 (04/08/02).
- STS–111 (06/05/02).

No launch delays were attributable to MSFC hardware issues.

Maintain less than one IFA per mission.

For FY 2002, the SSPO maintained an IFA rate of 0.20 per mission. This rate is below the target rate of 1.0.

Shuttle Integration Office

Publish and distribute the SEA Initiative Annual Report.

The SEA Annual Report for FY 2001 was published and distributed on December 7, 2001. The Report defines programmatic and technical accomplishments and activities for FY 2001.

Implement the Space Shuttle Program Electromagnetic Effects (EME) Action Plan in response to the Office of Special Council letter concerning potential electromagnetic interference issues.

The SSPO is implementing the Space Shuttle Program EME Action Plan requested in the Office of Special Council letter. Four of the five actions have been completed. Work on the Perform System Level Assessment action is ongoing. The SIO continues to implement the SSPO EME action plan.

Maintain a 90 percent customer satisfaction rate and document continuous improvement using input and feedback from the SSPO Web page.

The SIO has developed a customer satisfaction survey and made it available to its customers. The SSPO maintains a 100 percent satisfaction rate with its internal customers. No negative feedback has been received from external customers. The customer satisfaction survey and Shuttle Continuous Improvement activities are documented on the SSPO Web site.

Space Shuttle Main Engine

SSME Block II flights will be fully implemented during FY 2002.

The SSME Project fully implemented the use of Block II engines during FY 2002. One Block II engine was flown on STS–108 (12/05/01) and three Block II engines were flown on STS–110 (04/08/02). All subsequent flights will utilize Block II engines.

External Tank

ET will implement FSW for production of longitudinal welds.

The ET Project is implementing the use of FSW at MAF. Production Tool #1 was certified to weld flight hardware in October 2002 and is operational. The ET Project is evaluating implementing the new weld process earlier than on ET–134 as currently scheduled.

Reusable Solid Rocket Motor

The RSRM project will identify and reduce risks to flight hardware and personnel caused by human/process error by optimizing human-system interfaces. Industrial Engineering for Safety upgrades to be pursued include RSRM robotic glass bead, nozzle handling improvements, and high-pressure reciprocating pumps.

Implementation of robotic glass is nearing completion. The robotic glass bead upgrades are on schedule and within cost. Installation of the igniter system is complete and the system is undergoing checkout operations. Fabrication of the case and nozzle hardware systems has been completed. Vendor installation of nozzle/case booths and equipment are in progress. ETP–2012 nozzle testing completed. ETP–1987 Department of Energy testing is in work on glass bead igniter booth. Leasehold improvements were completed on July 2002.

Metrics

FY 2002 Space Shuttle Projects Office Metrics—continued

Reusable Solid Rocket Motor—continued

Implementation of the RSRM Washout Reciprocating Pumps has been completed. The nozzle handling improvements are on schedule and within cost. Installation of the Nozzle Lift Platforms has been completed and the platforms were released to production on 02/28/02. The M–5 handling devices and M–113 lift/manipulator devices are in final fabrication. The Dalmac sewing station manipulator has been received and the last three manipulators were delivered the first week in September.

Solid Rocket Booster

The SRB Project will satisfactorily complete the formulation phase for the IEA and Automated Booster Assembly and Checkout System (ABACS) supportability upgrades by mid-FY 2002.

The SRB Project Office completed the formulation phase for upgrades to the IEA and ABACS on May 2, 2002. Both upgrades were presented to the Space Shuttle Program Requirements Control Board and the IEA upgrade received funding authority for implementation in August 2002. The ABACS upgrade is being worked as part of the Service Life Extension Program.

The SRB will successfully continue the design, development, and qualification for the upgrade of the altitude switch assembly (ASA), within schedule and budget commitments. The ASA's function is to initiate the parachute recovery system for the SRB that allows the SRBs to be recovered from the ocean and reused.

The SRB Project Office has successfully continued the design, development, and qualification for the upgrade of the ASA during FY 2002. The ASA upgrade is on schedule and on budget. Development activities continue with assembly of the two qualification units complete and pretest screening in work. Delivery of the first flight unit is scheduled for February 2003.

Advanced Space Transportation Program

Again in FY 2002, MSFC has served as the NASA Center for the Advanced Space Transportation Program (ASTP). ASTP has continued to develop key technologies needed to fly a third generation of reusable space-launch systems by 2025 and a fourth generation by 2040; these future space-launch systems must provide significant increases in safety and operational flexibility while decreasing cost. ASTP has also developed projects for advanced in-space propulsion to push payloads from Earth orbit to the planets and beyond; these projects will enable interplanetary payloads to carry more mass, reach their destination sooner, or both.

ASTP must develop a wide range of technologies through projects not only at MSFC but other NASA Centers—including Langley, Glenn and Ames Research Centers. The focus of ASTP work at MSFC has been propulsion and propulsion-related work. While most of the effort was directed at chemically fueled systems, a limited amount of highly futuristic research addressed the challenges of all-new energy sources—even antimatter systems. Technologies for advanced materials, material process, and subsystems are also a part of the ASTP work to make vehicles and their propulsion systems perform better, in part by being lighter, stronger, and safer. Personnel at aerospace companies and at universities across the U.S. have joined with NASA to pursue these and other ASTP technology objectives.

Hypersonics Program Development

The third generation, reusable, hypersonic space-launch systems being enabled through ASTP are conceived as airplane-like vehicles that use air-breathing propulsion for the initial phases of flight. Hypersonics refers to flight at five or more times the speed of sound—i.e., Mach 5 or greater. ASTP has been developing combined-cycle propulsion systems that can push a space-launch vehicle from takeoff to hypersonic speeds, with rocket power required for the final surge to orbit. Such vehicles are conceived as using a particular mode of propulsion for each of a series of speed ranges. Maximizing the integration of a combined-cycle propulsion set—which must operate effectively all the way from takeoff to orbit—typically results in higher vehicle performance.

These one- or two-stage vehicles would be reusable and offer many of the measures of flexibility and reliability featured by conventional supersonic aircraft: takeoff and landing via runways, as well as turnaround time of days on the ground between flights to space. NASA's plans call for working closely with the Department of Defense (DOD) to develop hypersonic vehicle technologies. Some resources have been allocated to demonstrating the performance and operability of two types of combined-cycle propulsion systems with ground test engines (GTEs). Other ASTP resources have been planned for several in-flight propulsion-system demonstrations, including those for supersonic-combustion ramjets (scramjets) at speeds up to Mach 10. Remaining resources have been allocated to solving key challenges for structures, materials, and subsystems for both propulsion and airframes.

Rocket-Based Combined Cycle/Integrated System Test of an Air-breathing Rocket

The Rocket-Based Combined Cycle/Integrated System Test of an Air-breathing Rocket (RBCC/ISTAR) Project is a risk-reduction activity to advance the state-of-the-art for RBCC engines through design, development, fabrication, and test of a GTE. An RBCC engine is one in which rockets are integrated within the air-breathing, dual-mode, ramjet flow path such that they thermodynamically impact one another. The rockets provide thrust up to the point where the ramjet achieves enough compression of the ingested air to produce positive thrust, typically about Mach 3. As Mach number increases further, the aerodynamics of the flowpath change until all internal flow is supersonic, at which point the engine is termed a scramjet. This generally occurs by Mach 7.

After conducting thorough trade studies and factoring in ongoing activities in other hypersonic programs nationally, the RBCC/ISTAR Project has determined the propellants to be JP–7 and 90 percent Hydrogen Peroxide (H_2O_2). The GTE phase will be considered successful if an RBCC engine is designed and fabricated within budget constraints and on schedule milestones and it is tested in all modes: air-augmented rocket, ramjet, and scramjet. The engine performance shall, after an additional flight-design iteration, be sufficient to accelerate a self-powered vehicle from Mach 0.7 to scramjet takeover around Mach 7.

The Contractor Consortium and NASA teams completed a complete Systems Requirements Review (SRR) for the flight version of the RBCC/ISTAR engine in September 2002. Completing the SRR for the flight vehicle concept helps facilitate flight requirements flow-down to the design of the GTE. This requirements flow-down will ensure the GTE phase provides risk mitigation for a future flight engine development.

Program Transition

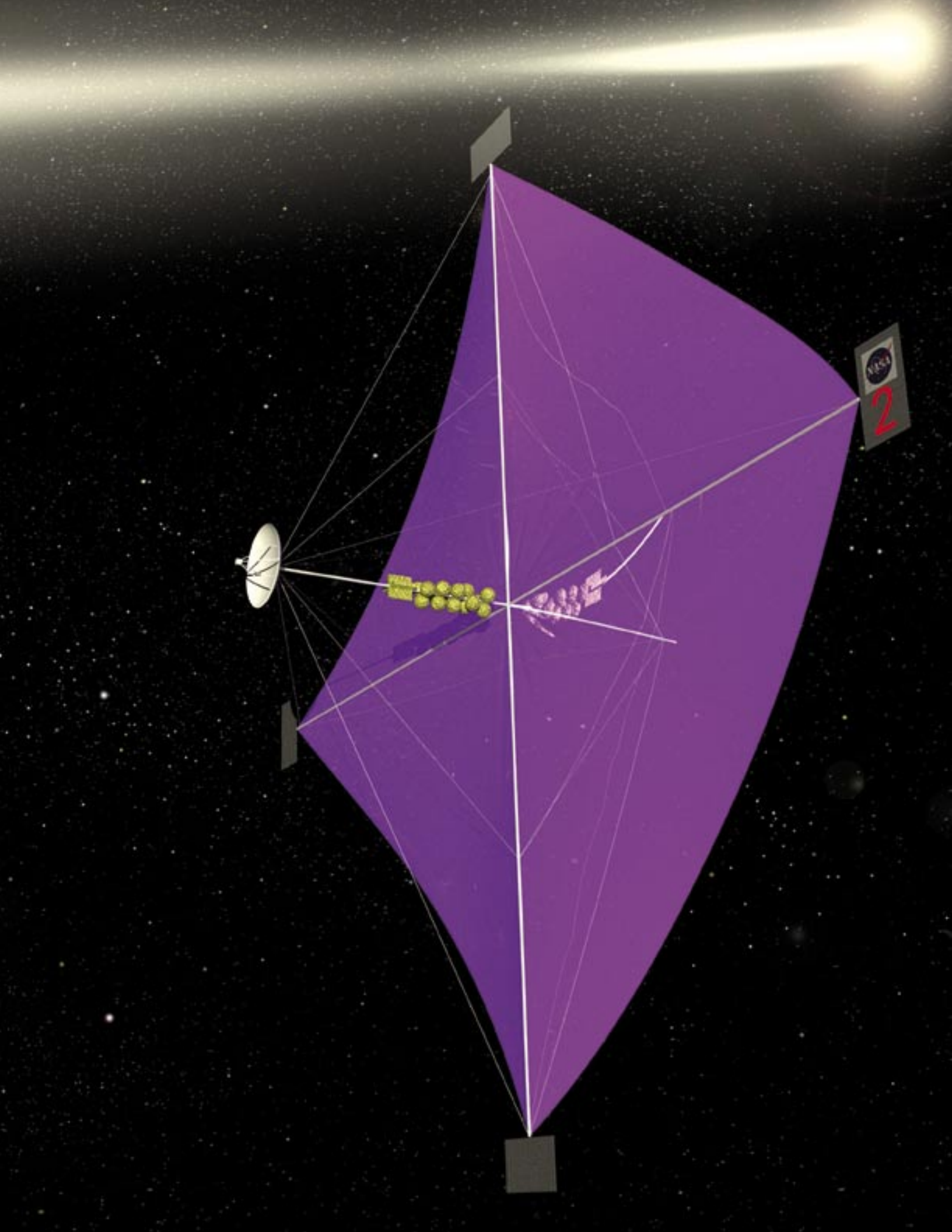
In FY 2003, NASA combined ASTP projects and rocket-propulsion projects from the Space Launch Initiative (SLI) program into something new—the Next Generation Launch Technologies (NGLT) Program. That program has continued those project sets with relatively little change in plans. This consistently reduces risk for a series of decisions that will use those technologies in enabling not only expendable but also reusable space-launch systems of the future.

Metrics

FY 2002 Advanced Space Transportation Metrics

Complete SRR on RBCC demonstrator engine.

The SRR was held on June 25–26, 2002. The Final Review Board and SRR closeout was held September 27, 2002.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In-Space Propulsion

MSFC supports NASA's objectives of reducing space transportation cost and enabling faster space travel times. In June, NASA's Office of Space Science selected teams to lead development of ion engine and other advanced propulsion technologies. The In-Space Propulsion (ISP) investment area of Transportation Directorate (TD) is the implementing organization of this NASA Headquarters-managed program. Future scientific exploration missions present unique challenges. Two principal challenges are fast access throughout the solar system and the ability to rendezvous with and orbit planets, their satellites, and other small bodies.

The approach has been first to identify and prioritize the most promising technologies using system analysis and peer review; and then to develop mid-technology readiness level (TRL) technologies to TRL 6 for infusion into mission planning within 3–5 years. To date, two awards have been made via a NASA Research Announcement (NRA) for next generation ion electric propulsion technologies. NASA released the ISP Technologies Cycle 1 solicitation, which included areas such as aerocapture, solar sails, tethers, etc. The selections were announced in August 2002. The Cycle 2 solicitation of ISP Technologies was released with selections anticipated in the second quarter of 2003.

The goal of the ISP investment area to research and develop innovative propulsion systems is paramount to the NASA vision. Utilizing advanced propulsion technologies will maximize NASA's return on investment in future missions by enabling spacecraft to quickly and safely reach all points throughout our solar system and beyond.

MSFC's ISP team works in partnership with Glenn Research Center (GRC) in Cleveland, OH; Langley Research Center (LaRC) in Hampton, VA; the Jet Propulsion Laboratory (JPL) in Pasadena, CA; the Ames Research Center (ARC) in Mountainview, CA; and other NASA field Centers, as well as government, industry, and academia throughout the Nation. Some of the propulsion technologies being investigated by TD's ISP team are described below:

Aerocapture Technology

Aerocapture is an aeroassist technology that uses a planet's atmosphere to slow a craft to orbital velocity with greatly reduced use of rocketry. Aerocapture would eliminate the need for heavy onboard fuel loads, which have limited vehicle performance, mission duration, and mass available for the science payload. This virtually fuel-free method of retropropulsion could reduce the weight of a spacecraft by half or more, enabling NASA's missions with smaller, more economical vehicles.

Solar Sail Propulsion

Solar sails have been studied for a variety of missions and have the potential to provide cost effective, propellantless propulsion that enables longer on-station operation, increased scientific payload mass fraction, and access to previously inaccessible orbits e.g., non-Keplerian and high solar latitudes. This year, effort began for a significant ground demonstration of a solar sail system-engineering model. Tools for orbital mechanics and attitude control are being developed. Planning for 2003 calls for focus on near-term solar sail technology areas: integrated solar sail diagnostics for in-flight sensor systems, high-fidelity computational models, and quantitative laboratory characterization testing of materials. Planning for FY 2004 calls for focus on electrostatic charging issues. The goal of this activity is to produce a TRL 6 solar sail propulsion technology by FY 2008.

Next Generation Ion Propulsion

Today, the standard for ion thrusters is the NASA Solar Electric Propulsion Technology Application Readiness (NSTAR) Thruster. This 30-cm diameter thruster flew as an experiment on Deep Space 1, launched in 1998. The NSTAR thruster demonstrated 30 mN of thrust at 2.3 kW and Isp of ~3,100 sec.

The purpose of the Next Generation Ion activity is to advance ion propulsion system technologies further through development of the NASA Evolutionary Xenon Thruster (NEXT). The goal of NEXT is to improve power capability and propellant throughput—the total amount of propellant that can be processed—by more than 100 percent, while increasing the Isp by 30 percent and the thrust by 120 percent.

Emerging Propulsion Technologies

Momentum-exchange/electrodynamic reboost (MXER) tethers and plasma sails are high technical risk/high potential payoff technologies being investigated by the ISP team. A representative MXER tether is a 100-km long rotating tether in an elliptical orbit around the Earth. At perigee, the tip of the tether would catch a payload in low Earth orbit, and then throw it into a much higher energy orbit. The tether acts on the principle

An artist's concept of a solar sail.

Metrics

FY 2002 In-Space Propulsion Metrics

Release NRA for next generation ion propulsion.

The NRA for Next Generation Ion Engine Technology was released as an amendment to NRA 01-OSS-01–NGLT, released in January 2001. The amendment was issued in November 2001 with proposals due in January 2002. Selections for subject NRA amendment were awarded in June 2002.

Release NRA for ISP transfer technology.

The NRA for ISP transfer technology, NRA 02-OSS-01–ISTP, was issued in January 2002 with proposals for cycle 1 due in April 2002. Selections for subject NRA were awarded in August 2002.

FY 2002 Propulsive Small Expendable Deployer System Metrics

Fly ProSEDS tether-propulsion flight experiment.

The ProSEDS tether-propulsion flight experiment was originally scheduled to fly in April 2001 as a secondary payload on USAF Delta-II GPS replacement mission. Due to delays of the USAF-scheduled mission, the ProSEDS launch date has subsequently seen delays.

The current USAF schedule shows the launch of the Delta-II GPS, with the ProSEDS secondary payload, to be March 2003.

of momentum exchange—the transferring of momentum from one body to another. This momentum energy would then be restored to the reusable tether facility by driving electrical current through the tether and pushing against the Earth's magnetic field. By this sequence of operations the tether provides a spacecraft high thrust into higher orbits with high specific impulse—propellantless propulsion.

Plasma Sails

Plasma sails might result from creation of large electromagnetic bubbles, electrostatic particles, or superconductive rings in space that would be propelled by the solar wind. If such technology is proven, this could accelerate a spacecraft to high velocities with little or no propellant. These and other potential prospect technologies are being considered within Emerging Propulsion Technologies.

Advanced Chemical and Thermal Propulsion

Advanced chemical and thermal propulsion technology development will concentrate on investments that focus on a reduction of trip time or propulsion system mass savings. Current and/or planned chemical investments are:

1. Advanced Propellants: Evaluation of high-energy storable propellants and additives.
2. Cryogenic Fluid Management: May enable both multiyear storage of cryogens and their transfer in space.
3. Lightweight Components: Cross-cutting lightweight or optimized components, material, and manufacturing technology to reduce the mass of chemical and electric propulsion systems. The current thermal investment applicable to the Office of Space Science goals is Solar Thermal Propulsion. This investment is comprised of NASA directed tasks that are addressing fundamental technical questions. Answers to these questions should help determine the feasibility of investment in this area.

Technology Planning and Systems Analysis

The ISP team established a systems analysis team to drive out and substantiate technology investment needs, which consequently brought about the formulation of a multi-Center NASA and contractor systems analysis team. The team performs and studies systematic and periodic analyses to provide critical data for the technology investment areas to use in determining funding priorities and direction. Efforts of the team provide quantitative data necessary to measure the benefits of each technology area, thereby identifying and understanding technology requirements, and gaps.

Propulsive Small Expendable Deployer System

Preparations continued at the MSFC in 2002 for the first in-space demonstration of an electrodynamic tether-based propulsion system. Developed by MSFC, this experiment will use an electrodynamic tether to lower the orbit of a spent rocket stage. The Propulsive Small Expendable Deployer System (ProSEDS) is a secondary payload on a Delta II U.S. Air Force (USAF) global positioning system (GPS) mission. As a secondary payload, the experiment is dependent on the USAF GPS launch schedule. Inexpensive and reusable, ProSEDS technology has the potential to turn orbiting, in-space tethers into space tugboats, thereby replacing heavy, costly, traditional chemical propulsion and enabling a variety of space-based missions, such as the fuel-free raising and lowering of satellite orbits. System and component testing of ProSEDS flight hardware has been completed.

Propulsion Research Laboratory

Missions to the outer solar system—and eventually to other stars—will require performance well beyond even those capabilities needed for interplanetary flight. In 2002, NASA's Propulsion Research Center, a national resource housed at the MSFC for advanced propulsion research, completed detailed design for its new multimillion dollar, state-of-the-art Propulsion Research Laboratory (PRL). Public hearings to discuss the environmental assessment for the PRL were held early in the year, and the PRL groundbreaking ceremony was held in July. Construction of the 66,000-square-foot laboratory began in August on its 21-acre site on Redstone Arsenal. Construction is planned for completion in early 2004.

Once the facility is completed, scientists and engineers from NASA, industry, academia, and the U.S. Departments of Energy and Defense will pool their resources on-site. They will perform landmark propulsion research, extending current research being conducted in the Propulsion Research Center, which will set the stage for a broad range of evolutionary and revolutionary space flight applications. Research and subscale experiments will be conducted in a number of areas, including advanced chemical propulsion, propulsion energetics, solar propulsion, electromagnetic propulsion, propellantless propulsion, and high-pressure combustion research.

Pictured is an artist's concept of NASA's ProSEDS experiment.

The state-of-the-art PRL will serve as a leading national resource for advanced space propulsion research.

Metrics

FY 2002 Propulsion Research Laboratory Metrics

Complete PRL detailed design and begin construction.

The PRL detailed design was completed early in 2002, and a public groundbreaking ceremony was held in July 2002. Construction of the laboratory was begun in August, with expected completion scheduled for early in 2004.

OSP DESIGN PHILOSOPHY

- We are designing an entire system, not just a spacecraft.
  - The system design includes all activities and processes that interface with hardware and software, contributing to the mission it is intended to perform.
  - The system design includes only those interfaces that add real value.
- We are designing for complete operations.
  - Operations include everything hardware and software sees (interface) from the moment it is an idea until it is retired.
  - Operations include all designs that result in safe, reliable, maintainable, and supportable hardware and software.
- We will eliminate, minimize, or simplify all interfaces, including:
  - Applicable documents, parts tracking, payload integration, inspection, sustaining engineering, packaging, shipping, tooling, facilities, logistics, training, test, verification, disposal, people, analyses, reviews, approvals, and so forth.
- We will manage the requirements and system design with currently available technology to meet Program schedule and cost goals.
- We are designing the total system for simplicity, even if some flight components become heavier or more complex.
- We are each responsible for looking at the entire system, asking the right questions, and minimizing system complexity and cost.

Space Launch Initiative 2nd Generation Reusable Launch Vehicle Program

Managing the Business of Technology

In its second year of operation, the SLI continued business and technical advances to reduce the risk of developing a future generation of Reusable Launch Vehicles (RLVs) for America's vital missions. Through business planning and development, architecture design, and technology advancements, SLI made measurable progress as planned, on schedule, and within budget. The diverse SLI team reflected One NASA, with participation from all NASA Centers and many contractors from coast to coast. Their combined work provided the information that enabled a reevaluation of the Agency's broad-based Integrated Space Transportation Plan (ISTP) in support of current National needs. This helped establish a joint NASA/DOD plan and roadmap to clarify the critical mass of funding needed for breakthroughs in propulsion.

During FY 2002, the SLI team developed the systems and tools—including a Stakeholder Relationship Management System—to effectively manage the Nation's investment and, thereby, ensure fiscal accountability as directed by the President's Management Agenda. The Interim Architecture and Technology Review (IATR), completed in March 2002, focused hundreds of potential RLV system designs to the 15 most promising concepts. Analysis conducted in the Advanced Engineering Environment (AEE) identified key technology drivers needed for those designs to be built and become operational. Propulsion, the largest contributor to safety, reliability, and affordability in a new RLV, proved to be the Program's top technology challenge. NASA-unique systems for crew safety and survival emerged as the top design challenges, since development depends primarily on Government funding. The SRR, scheduled to begin in FY 2003, was put on hold in September 2002, as directed by NASA Headquarters. In addition to the joint NASA/DOD 120-Day Study, the 2nd Generation RLV Program conducted a crew transfer/crew rescue vehicle study, concluding that NASA mission requirements for a multipurpose Orbital Space Plane (OSP) are feasible for *ISS* increased crew size and research capability.

Integrated Space Transportation Plan Revised

From its inception in February 2001 to its redirection in November 2002, the SLI 2nd Generation RLV Program delivered the business and technical information that refocused strategic direction within NASA. The revised ISTP, announced in November 2002, elevates SLI to a Theme within the NASA Aerospace Technology Enterprise, with the goal to: (1) develop an OSP system in the near term, as well as (2) support RLV decisions within the NGLT Program. In FY 2003, SLI—formerly a two-pronged initiative for architecture design and technology development—will reallocate resources. Architecture design is refocusing on a crew rescue/crew transport system, while SLI technology projects such as propulsion have moved into the NGLT Program, along with other advanced technology efforts.

NASA's aerospace industry partners are designing an integrated system capable of meeting NASA's mission requirements for *ISS* crew rescue around 2010, and crew and cargo transport around 2012.

As the architecture designs in the SLI Program transition to the OSP Program, a lean, value-added organization based on industry best practices has been established. Flight demonstration projects such as the X–37 will ensure implementation of proven technology within a fully integrated system. Established business systems and agile acquisitions will require continued accountability, flexibility, and disciplined innovation in the design and development of the first OSP—a new National asset. As the *ISS* International Partners move beyond the Core Complete Phase, a new era of scientific discovery will begin. Enabled by increased capabilities for crew rescue and transport provided by the OSP system, this unparalleled research facility will further NASA's vision to improve life here, extend life to there, and find life beyond.

Metrics

FY 2002 2nd Generation Reusable Launch Vehicle Program Metrics

Develop a comprehensive Stakeholder Relationship Management System that defines what is important to individuals and groups, measures satisfaction, implements corrective action, and provides mutual development of future requirements.

The Stakeholder Relationship Management System was developed as a series of comprehensive, integrated listening posts to determine what is going on in both macro- and microenvironments, particularly among various stakeholders. These data were utilized to improve the systems and processes that impact SLI performance the most. It also identified which SLI roles, technologies, or initiatives are the most important for unfolding the future with stakeholders.

Establish an AEE to provide a state-of-the-art computer-aided design/computer-aided engineering capability that enables concurrent systems analysis and design among geographically dispersed Government, industry, and university teams.

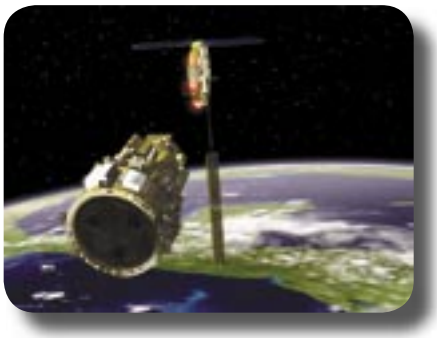
The AEE is a state-of-the-art systems engineering tool that links analysis groups at decentralized sites to collect and validate data, saving valuable time and travel costs. The capability to conduct real-time high-fidelity mission analysis led to the AEE being recognized by NASA's Office of Aerospace Technology as a top enterprise innovation in April 2002.

Conduct the IATR to ensure that processes and plans are in place to successfully achieve an SRR, and to ensure that work is proceeding to complete necessary products and analyses for the SRR.

The IATR, completed in March 2002, narrowed over 100 architecture designs to 15 possible candidates. The AEE was a prime resource for validating trade studies and aligning technology investments with the architecture concepts selected. The SRR was put on hold by the Aerospace Technology Associate Administrator pending results of the ISTP study that resulted in SLI's transition to the OSP Program and the NGLT Program.

The X–37 Approach and Landing Test Vehicle systems verification assessment was completed and vehicle manufacturing began, preparing for flight demonstration in 2004.

The X–37 Approach and Landing Test Vehicle is being assembled for flight demonstration in 2004.



Demonstration of Autonomous Rendezvous Technology (DART) will autonomously rendezvous with an on-orbit spacecraft, as depicted in this artist's concept, to enable new capabilities for *ISS* servicing.

2nd Generation Reusable Launch Vehicle Propulsion Office

During FY02, the 2nd Generation RLV Propulsion Office of the SLI completed a number of milestones toward the goal of reducing the risks for developing a new generation of safer, more reliable, and less costly propulsion systems for a new generation of RLV. Shortly after FY 2003 began, the revised ISTP was announced, and SLI was elevated to a Theme within NASA's Office of Aerospace Technology. Subsequently, the SLI 2nd Generation RLV Program was divided into two major programs: part of the NGLT Program and all of the OSP Program. The 2nd Generation RLV Propulsion Office transitioned to the NGLT Program along with other advanced technology projects (e.g., the ASTP), while architecture design and flight demonstration projects moved to the OSP Program.

The SLI Program's first major milestone, the IATR, was completed in March 2002. Based on architecture needs outlined in the IATR, a contract option was exercised to design a first-stage engine that uses liquid oxygen (lox) and purified kerosene (RP). Using lox/RP in the first stage of launch could lower maintenance costs and provide a safer overall architecture, capable of drastically reduced turnaround time for the next launch. This research also helps satisfy the safety and reliability needs of a 2nd Generation RLV, as well as some commercial and DOD requirements. The RS–83 and Co-optimized Booster for Reusable Applications (COBRA) liquid oxygen/liquid hydrogen (lox/LH_2) projects had completed major reviews and delivered sound information; those contracts were descoped or allowed to expire after the contract period of performance ended in September 2002 as a result of the ISTP-based reorganization. As a result, the lox/LH_2 propulsion knowledge database has been significantly expanded and is now available for future development, while major research on lox/RP propulsion continues.

Major 2nd Generation RLV Propulsion milestones included the SRR that demonstrated significant evolution of propulsion designs toward meeting the SLI goals of enhanced safety, increased reliability, and reduced cost. Noteworthy manufacturing and testing of full-scale component milestones were also accomplished, including over 15,000 seconds of hot-fire testing. This testing encompassed preburners; reaction-control thrusters using nontoxic propellants that are safer for the environment, lower costs, and increase efficiency; and a state-of-the-art electromechanical actuator that offers potential safety and efficiency improvements over the older pneumatic and hydraulic-fluid systems currently used in the aerospace industry. Miniaturized leak-detector technology was studied as part of an advanced Engine Health Management System that could provide real-time diagnostics to supplement decision-making, as well as save valuable vehicle turnaround time by identifying potential processing-problem areas.

In concert with the U.S. Air Force, basic research was conducted on the use of safer peroxide upper-stage fuel, including materials compatibility and detonation. Initial testing of the Integrated Powerhead Demonstrator, developed through a partnership with the Air Force Research Laboratory, was conducted to demonstrate start-up and operation characteristics of a full-flow, staged-combustion rocket engine.

The newly created NGLT Program will continue next generation RLV technology development activities, including RLV booster research and 3rd Generation RLV hypersonics—an effort that is well integrated with DOD and promotes long-term technology breakthroughs. The updated ISTP provides a schedule that facilitates understanding and integration of DOD requirements in conjunction with NASA's strategic plan. Ultimately, the NGLT Program will enable future launch system development decisions to support NASA's far-reaching space transportation requirements in the coming decades.

Metrics

FY 2002 2nd Generation Reusable Launch Vehicle Propulsion Office Metrics

Complete the Critical Design Review (CDR) for the Crossfeed Checkvalve Test Article.

The CDR for the 4-in, subscale, crossfeed check valve was completed, which permitted fabrication of the crossfeed test valve and successful water-flow testing. A crossfeed system enables the booster and orbiter engines on a potential two-stage-to-orbit vehicle to fire simultaneously at ascent, verifying the integrity of the orbiter engine prior to orbit.

Perform the workhorse engine tests for the Auxiliary Propulsion System Reaction Control Engine.

Tests were successfully performed on workhorse Northrop Grumman (formerly TRW) and aerojet reaction control engines (RCEs). The RCE concepts using nontoxic lox/ethanol propellant combinations for safer ground operations will increase efficiency, with less maintenance required for faster turnaround times between missions over current toxic propellant thrusters. Additionally, the RCEs have dual-thrust capabilities, which allow coarse and fine vehicle-attitude adjustments in a single engine.

Complete final testing of the monopropellant gas generator for powering turbine drives.

Final tests were successfully completed on a high-performance hydrogen peroxide monopropellant gas generator. The tests demonstrated a robust design of a monopropellant gas generator to power-turbine drives capable of throttling up and down.

Design and build a hypergolic injector for orbital propulsion.

An advanced hypergolic injector system was designed, built, and delivered to the Stennis Space Center for testing. This injector system uses a proprietary hydrocarbon-blended fuel, which creates spontaneous ignition when combined with hydrogen peroxide. Low-toxicity propellants and the ability to function without a separate igniter provide significant advancement over traditional injector technology.

Complete the RS–83 System Definition Review.

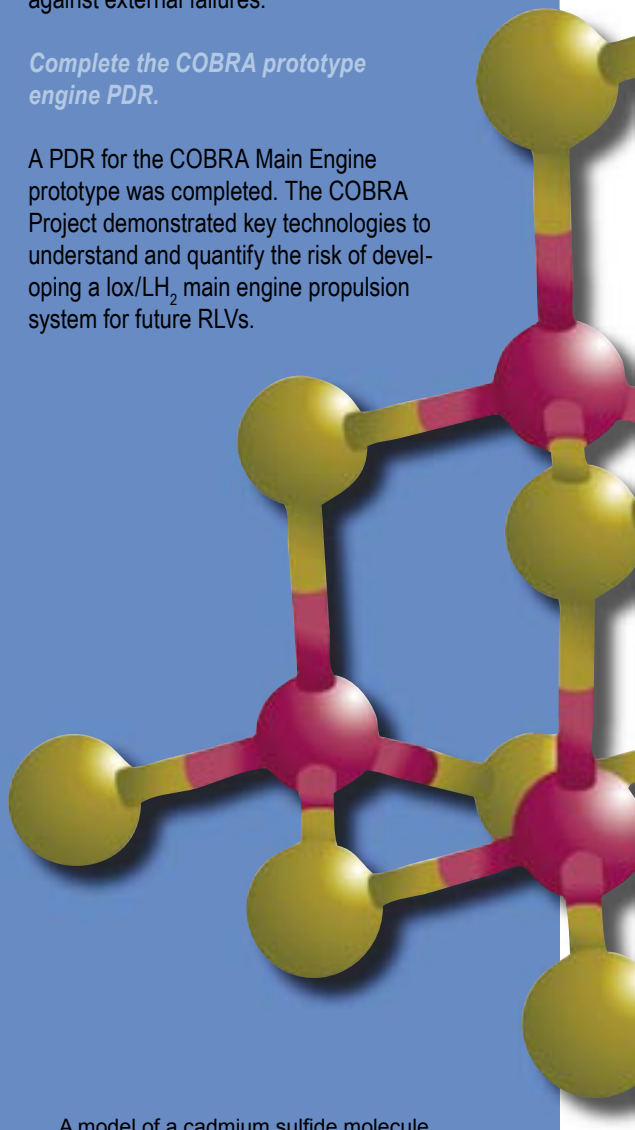
The RS–83 Main Engine Project successfully completed a Systems Definition Review—a major milestone that defined the flowdown of requirements to all functional system elements and ensured that the design project was mature enough to continue to Preliminary Design Review (PDR).

Complete the COBRA Powerhead CDR.

The COBRA Main Engine Project completed a CDR of the powerhead component. The self-safing, double-walled powerhead enhances safety by protecting against external failures.

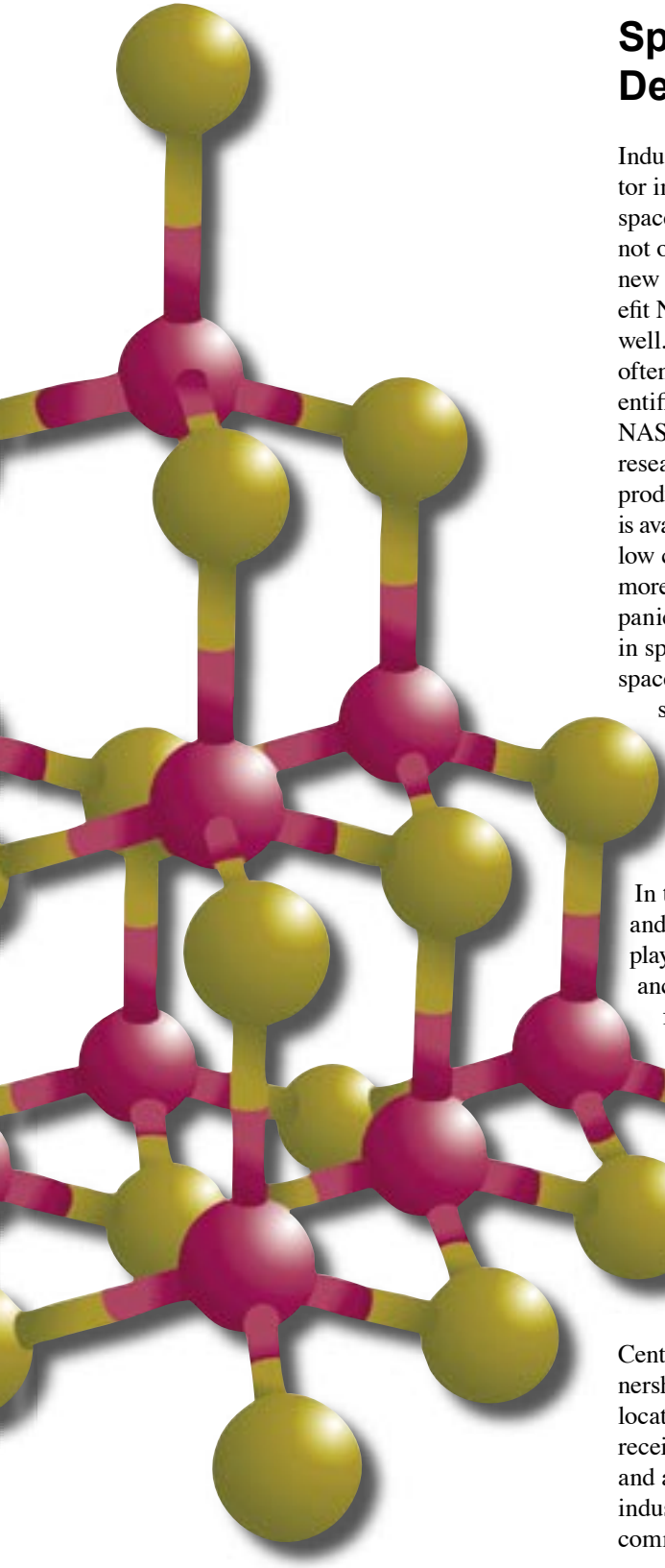
Complete the COBRA prototype engine PDR.

A PDR for the COBRA Main Engine prototype was completed. The COBRA Project demonstrated key technologies to understand and quantify the risk of developing a lox/LH_2 main engine propulsion system for future RLVs.



A model of a cadmium sulfide molecule. Fabrication of the molecule in microgravity may allow for improvements in a variety of electronic devices

Microgravity



Space Product Development

Industrial partnerships are a key factor in improving life on Earth through space research. These partnerships not only enable the development of new products and services, they benefit NASA missions in other ways as well. Industrial partner research is often complementary to NASA scientific research objectives, enabling NASA to benefit from industrial research. The commercial program produces research flight hardware that is available to the science community at low cost, thereby making research more cost-effective. By helping companies understand what can be done in space and by helping them develop space capabilities, the seeds of new space industries are planted. These new space industries will make it possible for NASA to embark on a visionary sustainable exploration program.

In the history of human exploration and discovery, commerce has always played an important role. From ancient sea traders, to 18th century fur trappers, to the envisioned helium miners on the moon, industry has helped to push the boundaries of the frontier. NASA is encouraging businesses to seize the commercial space opportunity through the Research Partnership Centers (RPCs). The RPCs are partnerships in the finest form. Usually located at academic institutions, they receive base funding from NASA and are charged with working with industry to pursue specific areas of commercial research.

Bristol-Myers Squibb (BMS), partnering with BioServe Space Technologies, an RPC, has conducted microbial fermentation research on the Space Shuttle, which has shown that the production of antibiotics is substantially greater in microgravity than in comparable experiments on Earth. Long-term adaptation research is planned using the *ISS*. The goal is to develop a way to reproduce the increase in metabolic efficiency observed in space in order to improve antibiotic production rates on the ground.

Taconic Farms, Inc., of Germantown, NY, is a new industrial partner of BioServe and is the leader in commercial production and worldwide distribution of transgenic rodent models used in basic research, drug discovery, and safety testing protocols. BioServe affiliate Dr. Stephen Keith Chapes at Kansas State University developed a knockout mouse model that can provide researchers with a beneficial tool for testing AIDS drugs, HIV vaccines, and other respiratory drug treatments. Taconic bred the transgenic mouse model through its Emerging Models Program for Kansas State University.

BioServe's first flight onboard STS–108, in collaboration with Amgen, Inc., examined the effects of an Amgen discovered protein, Osteoprotegerin, on reducing the bone loss that occurs while in space. This protein is being developed by Amgen to treat osteoporosis, a major health threat in over 28 million Americans. Their second mission, an extended duration antibiotic fermentation research experiment conducted in collaboration with BioServe's long time partner BMS, flew successfully on board the *ISS* Increment 8A. BioServe and BMS are currently analyzing samples to determine the mechanism or mechanisms behind previously observed increases in production of antibiotics produced

in space. Understanding these mechanisms may improve efficiency of Earth-based fermentation facilities and thereby reduce the production costs of manufacturing antibiotics.

Recent studies at the Center for Commercial Applications of Combustion in Space (CCACS), an RPC, have found that the presence of SiO_2, TiO_2, and Al_2O_3 appear to enhance the formation of a hydroxyapatite film on a tri-calcium phosphate substrate placed in a simulated body fluid, while the lack of such constituents, or the presence of a more reactive component (MgO), appears to inhibit the formation of such a layer. These results are important for understanding how a calcium-phosphate material, like those now being synthesized routinely in CCACS, becomes integrated with the natural bone structure, and they provide guidance for the design of biodegradable implants.

The Center for Biophysical Sciences and Engineering (CBSE), an RPC, with its many industrial partners, is at the forefront of commercial microgravity crystallization research and structural biology and drug development. The Center has participated in protein crystallization experiments conducted on 41 Space Shuttle flights. The results from these experiments demonstrated that the microgravity environment can produce dramatic improvements in the size and x-ray quality of protein crystals. In several cases, scientists were able to locate features that were unobtainable using Earth-grown crystals, like drug molecules interacting with target proteins. The total amount of microgravity x-ray diffraction data was more than twice that produced by the best diffracting Earth-grown crystals. The *ISS* will give this research an even greater edge.

CBSE's work has led to the development of several novel technologies that are accelerating structural biology and drug development. Working in space often stimulates innovations with application on Earth. The Center wanted to place a complete x-ray facility on the *ISS* to characterize proteins on orbit to speed analysis and to protect samples from the forces of reentry. However, a conventional laboratory x-ray system is larger than a kitchen table, weighs more than 1,500 kilograms, and requires more than 6 kW of power. In less than three years, the center and its commercial partners developed a 60-lb x-ray system the size of a slide projector and requiring only 40 W of power. The complete facility robotically harvests protein crystals and cryopreserves them for diffraction characterization on orbit and return to Earth. CBSE also recently developed a high-throughput nanocrystallization system that robotically prepares protein crystallization experiments in droplet volumes less than 15 nl. They also developed new crystallization systems that dynamically control critical parameters that affect the quality and size of the crystals in ground-based laboratories and in space. Some of these technologies are now being used, or are being marketed for use, in laboratories around the world, making an important contribution to the revolution currently taking place in high-throughput structural proteomics. The combination of the Center's unique and powerful Earth and space capabilities led to a partnership with the genomics company Athersys, Inc., and to the formation of a new pharmaceutical company, Oculus Pharmaceuticals, Inc. Athersys has a proprietary technology that can rapidly provide genome-wide expression of any eukaryotic protein. Oculus uses licensed Center technology and Athersys's genome-wide expression of protein to develop faster and more cost effective therapeutics.

The Wisconsin Center for Space Automation and Robotics (WCSAR), an RPC at the University of Wisconsin at Madison, advances agribusiness research in space and on the ground. Commercial activities are divided into two categories—transgenic plant materials and products, and natural plant materials and products. In addition, they provide industry partners with advanced environmental control technologies, large-scale controlled environment plant production facilities, and automation technologies. Plant growth research has resulted in an increased rate of gene transfer, opening the door to the possibility of improved crops and nutraceuticals. WCSAR and its industry partner, Producers Natural Processing, Inc., are investigating ways of transferring commercially valuable genetic traits such as Human Interest Proteins (HIPs) into selected plants and converting the plants into a HIP production biofactory for pharmaceutical production. Gene transfer in the microgravity environment has demonstrated a tenfold increase in the efficiency of transient expression. This transfer expands the DNA structure of the target cell with the desired trait. The research and development objective is a hundredfold increase in efficiency for the multigenerational gene expression rate in subsequent generations. Production of these new genetically engineered varieties of species will carry traits of significant economic value, with projected product sales of $25 million the first year.

Metrics

FY 2002 Space Product Development Metrics

Maintain a ratio of non-NASA funding to NASA funding not less than 3:1 in FY 2002.

Maintained a 1.86:1 ratio of non-NASA funding to NASA funding in FY 2002. This year, for the first time, the funding for *ISS* hardware development provided by NASA to the CSCs is included in the NASA-funded side of the ratio. In past years, that funding was controlled by Code M and only recently came under control of Code U. The ratio, if calculated without the *ISS* funding included, would be 3.51:1.

Ensure that one of 39 product lines currently under investigation is brought to market in FY 2002.

Two products were brought to market in FY 2002. The Space Rose fragrance product discovered on STS–95 by WCSAR and their partner International Flavors and Fragrances was incorporated into a second product in FY 2002. The fragrance is now an ingredient in Impulse Body Spray and the variant Moon Grass marketed by Lever Faberge—part of Unilever—launched in January 2002 in the United Kingdom.

Solidification Design Center CSC Affiliate Flow Simulation Services of Albuquerque, NM, began marketing software that will enable improved process design of particulate molding processes. The software, ARENA-FLOW, is initially being marketed to the metal casting manufacturing industry, but future applications are being pursued in food and pharmaceutical production, aerosol drug delivery, and other biotech applications.

Enable at least 10 new active industrial partnerships to be established with the Space Product Development (SRB) RPCs.

Thirty-five new industrial partners were reported in FY 2002, easily surpassing the goal of 10. Companies identified are active in a variety of fields including technology development, human interest proteins, paper products, education, and computer systems. With permission of the industrial partner, the names of the companies can be made available. Otherwise, they are considered proprietary.

Launch and operate seven Space Shuttle SPD research investigations.

Launched and operated one Space Shuttle and seven *ISS* SPD research investigations.

FY 2002 Microgravity Research Metrics

Through the use of national teacher conferences and workshops, provide approximately 300 elementary and high school classrooms nationwide with electronic and printed materials that focus on activities in science, math, and technology relating to microgravity research and specifically written for students K–12.

This metric was met and exceeded.

In FY 2002, NASA's Microgravity Research Program's educational outreach activities continued to inform the public and inspire students toward careers in math, science, and technology by communicating how the Office of Biological and Physical Research (OBPR)'s space research mission benefits life on Earth and advances the capability of long-duration human exploration. The OBPR redesigned quarterly newsletter, Space Research, managed by the MSFC Microgravity Research Program Office (MRPO), has a current subscriber list of over 8,500 and is mailed to 38 countries. In FY 2002, the MSFC MRPO supported over 50 educational outreach and scientific conferences with speakers, materials, and exhibits. Several new educational briefs and posters were released in FY 2002, providing NASA physical science research content to thousands of teachers and students. The STS–107 mission brochure and associated payload fact sheets were developed, published, and distributed by the MRPO. OBPR scientists and educational outreach staff supported the STS–107 prelaunch event, "Countdown to Launch."

Launch and operate 12 ISS research investigations.

This metric was met and exceeded.

Launch and operate six Space Shuttle research Investigations.

Although this metric was not met in FY 2002, due to the delay of *Columbia*'s flight of STS–107 from July 2002 to January 2003, the metric was met in FY 2003.

Establish at least one process to monitor and evaluate customer satisfaction.

This metric was met through the distribution of multiple educational materials. Many of these elements contained customer satisfaction surveys requesting that participants provide feedback to this program practice. The program reviewed the findings of these surveys and adjusted its policies where possible.

Microgravity Science and Applications Department

The Microgravity Science and Applications Department (MSAD) within the Science Directorate at MSFC is responsible for implementing the Materials Science, Macromolecular Biotechnology, and Glovebox Programs for NASA. To implement the programs, the MSFC has a unique team of scientists, engineers, and managers teamed with industry, academia, and international individuals and organizations to establish, perform, and maintain world-class research in those fields. MSAD is also responsible for providing Glovebox facilities on the Shuttle and *ISS* for the purpose of supporting low-cost and fast-track investigations from all disciplines of the NASA Microgravity Program. MSAD is responsible for the financial and managerial administration of all selected Materials Science and Macromolecular Biotechnology investigations, assistance in the definition of focused science objectives, access to ground and flight facilities and carriers, definition and development of new enabling research technology, definition and development of scientific apparatus and facilities, missions operations support, and transfer of the accumulated microgravity database.

Biotechnology

NASA's Macromolecular Biotechnology Program set forth objectives for FY 2002 that would help achieve flight and ground support initiatives set forth in previous years. Flight program objectives centered on making flight opportunities available to a larger community of scientific researchers; facilitating research in the microgravity environment to produce high-quality crystals, and therefore structures, of challenging, high-impact problems; and expanding student and teacher participation in biological crystallization programs in the classroom and on the *ISS*. The focus of the ground program objectives were the development of technology and methods that will improve ways to preserve crystals, allow high-throughput crystallization methods and noninvasive monitoring techniques, and study the crystallization process in microgravity.

Opening the Flight Program to a Larger Community of Scientific Researchers—Creation of the NASA Institute for Structural Biology

NASA established the NASA Institute for Structural Biology (NISB) at the Hauptman Woodward Medical Research Institute (HWMI) in November 2001. HWMI is an independent, nonprofit facility specializing in basic research using structural biology, and founder Dr. Herbert A. Hauptman holds the title of Nobel Laureate in the science of crystallography. The goal of the NISB is to foster research in the field of structural biology and to facilitate the use of low gravity for research opportunities. In collaboration with NASA's Macromolecular Biotechnology Associate Investigator Program, NISB began notifying the structural biology community of research opportunities and began conducting independent peer-review of all structural biology/crystal growth samples that will fly on ISS. The chief duties of NISB will be to assist researchers by guiding them through the entire process of flying experiments on the *ISS* and to help investigators secure timely access to the Stanford Synchrotron Research Laboratory at Stanford University.

Facilitating Research in the Microgravity Environment that Produces High Quality Crystals—Challenging, High-Impact *ISS* Research Projects

Three missions took biological crystallization experiments to the *ISS* in FY 2002, and one mission returned samples that were launched in FY 2001. The Dynamically Controlled Protein Crystal Growth (DCPCG) experiment carrying two high-impact biological crystal growth experiments returned to earth in December of 2001. DCPCG was the first experiment in which experiments in space were conducted from the ground and the first microgravity payload that allowed automated imaging of the experiments in process. In early FY 2002, *ISS* assembly flight UF1 (STS–108) launched carrying 753 samples in the Protein Crystallization Apparatus for Microgravity (PCAM); assembly flight 8A (STS–110) transported 350 samples in the Enhanced Gaseous Nitrogen Dewar; and assembly flight UF2 (STS–111) transferred 378 samples in the PCAM equipment to *ISS* laboratories.

Detoxifying Superoxide Radicals

Especially noteworthy *ISS* research included results that were obtained on the first microgravity crystallization experiments on a manganese-containing form of superoxide disumutases (SODs), conducted on the *ISS* from December 2001 to April 2002 by Principal Investigator Dr. Gloria Borgstahl and her colleagues. Crystals grown in space showed an 80-fold increase in crystal volume compared with the largest earth-grown crystal. Diffraction data were collected to 1.26-Å resolution—a resolution that provides more than 86 percent more data than the best ground grown crystal. SODs are a species of antioxidant

enzymes that protect all living cells against toxic superoxide radicals that are involved in a number of diseases such as diabetes, heart disease, and cancer. The goal of Dr. Borgstahl's research is to study the chemistry of SOD at the atomic level as it performs its job of detoxifying superoxide. The role of manganese-containing SODs (MnSODs) in the body is important, and in-depth study of their structure is not only vital to understanding their function, but may lead to new therapeutics for treatment of various degenerative diseases.

Developing New Technology for High-Throughput Crystallization Methods and Non-Invasive Monitoring Techniques—Stamp-sized Laboratories for the *ISS*

NASA's Iterative Biological Crystallization (IBC) project began a collaboration with the renowned mass producer of LabChip® devices, Caliper Technologies Corporation (Mountain View, CA), to develop a new approach for conducting higher quality research in the study of the physical structure and physical chemistry of biologically important molecules on the *ISS*. The result is a technology that reduces the functions of a standard laboratory and a lab technician to a platform the size of a piece of glass slightly larger than a postage stamp. The lab-on-a-chip designed for NASA is the first hardware that can mix a prescribed recipe from up to five solution components and deliver them to one of two growth wells that reside on the same chip. Additionally, the IBC lab-on-a-chip system will allow a higher number of samples, higher throughput, and greater repeatability of experiments.

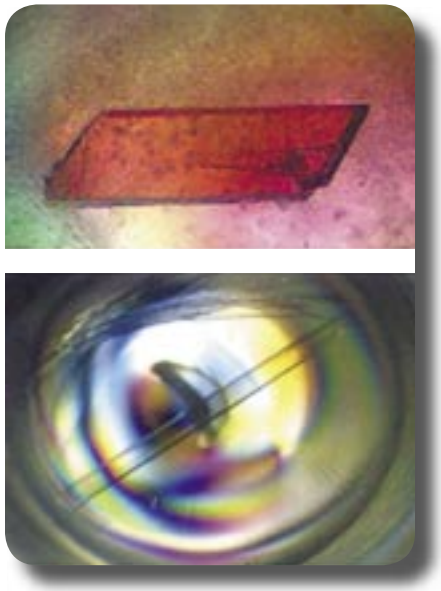
In the life sciences, lab-on-a-chip systems have diverse applications such as biochemical assays, genetic analysis, drug screening, electrochromatography, and blood-cell separation/analysis. In future space travel, miniaturized systems will be essential in reducing the upmass and volume of spacecraft systems. Lab-on-a-chip technology has the potential to facilitate and automate scientific research across multiple disciplines. As NASA seeks to develop tools that will diminish the negative effects of long-term space travel on humans, lab-on-a-chip technology is a potential springboard for medical diagnostic and therapeutic devices that will ultimately make spaceflight safer for humans.

Studying the Crystallization Process in Space Delta L—New Technology for Understanding Growth Rate Dispersion in Microgravity

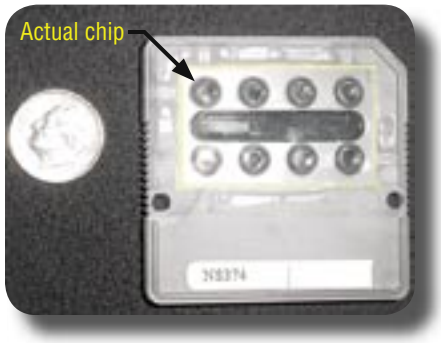
In FY 2002, engineers and scientists at MSFC completed production of the award-winning flight hardware given the name "Delta-L." The hardware will support an experiment to study the crystal growth characteristics of biological macromolecules in microgravity. This equipment, which will fly on *ISS* in late 2003, is expected to provide data that will test the hypothesis that growth rate dispersion plays a role in crystal quality improvement in microgravity. Growth rate dispersion is an occurrence in which individual crystals grow at slightly different growth rates under the same solution conditions. Scientists participating in the study believe that microgravity may act to improve crystal quality by reducing growth rate dispersion. A reduction in dispersion has been shown to be an indicator of quality crystals on the ground.

In late FY 2002, the Delta-L team learned that their imaging system, which will allow scientists to analyze their experiments on *ISS*, had won the prestigious Imaging Solution of the Year award from Advanced Imaging magazine. The award, which was selected as the best entry in the category of Microscopy, will appear

Dr. George T. DeTitta, Senator Hillary Rodham Clinton, Ron Porter, Dr. Herbert A. Hauptman, & Christopher T. Greene announce the creation of the NISB.



Upper: Microgravity-grown MnSOD crystal. The pink color is due to the manganese metal ion in the active site. Earth-grown crystals typically grow as thin plates and are never thick enough to see this vibrant pink color. Lower: Crystals taken at lower magnification.



in the January 2003 special issue of the magazine. The imaging system was chosen from many nominations for designs that merit special industry attention for their practical handling of digital imaging and image processing challenges.

Improving Ways to Preserve Crystals—Hot Views of Cool Crystals

Rapid cooling, or cryopreservation, is a technique routinely used to preserve crystals of biological molecules for x-ray diffraction structural analysis. Crystallization of biological molecules is a difficult task, and it is important that crystals are carefully preserved and stored. Not only must the crystals remain intact for later analysis—they must be able to withstand radiation damage from the intense x rays used. Flash cooling of crystals extends the crystal's lifetime and makes them less susceptible to secondary radiation damage that occurs during x-ray analysis. Cryocooling also reduces thermal motions of the molecules and allows for data collection from very thin or small crystals.

Drs. Edward Snell, Russell Judge, and Mark van der Woerd, MSFC researchers, have provided a method by which scientists, for the first time, can actually see images of the temperature gradients as crystals of certain molecules were rapidly cooled. Using a camera sensitive to infrared radiation, MSFC scientists captured the mechanical action and determined the length of time it took for the cryocooling process. The experiment also demonstrated that it is possible to observe defects created by improper cooling or handling. Results of the study were featured as the cover article of the November 2002 issue of the Journal of Synchrotron Radiation.

Expanding Student and Teacher Participation in Biological Crystallization Programs—Student Access to Space Program

The Student Access to Space Program, founded by Dr. Alexander McPherson of the University of California at Irvine, engages students in experiments dealing with the crystallization of proteins, nucleic acids, and viruses. The program involves special needs students, gifted students, and students in mainstream schools, rural schools, and inner city schools in hands-on, real flight experiments in structural biology. By the close of FY 2002, over 445 students and 264 teachers from over 235 schools in 11 states had participated in Flight Program workshops and actual launch of their experiments to the *ISS*. Over 1,135 teachers from over 390 schools across 40 states—including Puerto Rico and the District of Columbia—had direct involvement though Workshops, and have subsequently involved an estimated 35,000–55,000 students in classroom and ground-based laboratory activities. This education and outreach program has received widespread media coverage on the major television and radio networks, popular magazines and newspapers, and Internet Web sites dealing with space and science issues.

Publications

Approximately 70 peer-reviewed journal articles were generated from researchers in the MSFC Biotechnology Program. Many were presented at national and international conferences.

Microgravity Science Glovebox

The Microgravity Science Glovebox (MSG) was launched to the *ISS* on Assembly Flight UF2 (STS–111) in June 2002. Now installed in the Destiny module, the facility offers an enclosed scientific workbench area that is accessible to the crew through sealed glove ports and to ground-based scientists through real-time data links and video. To support experiment hardware, the work area provides a comprehensive set of experiment utilities, including power, imaging, data acquisition, and standard computer communications and control. Because the work area can be sealed and maintained at a slight underpressure, the crew can manipulate experiment hardware and samples without the potential hazard of small parts, particulates, fluids, and gases escaping into the open laboratory module.

Prior to the end of FY 2002, the MSG unit successfully supported a series of materials science experiment runs in two separate scientific investigations, the Solidification Using a Baffle in a Sealed Ampoule (SUBSA) and the Pore Formation and Mobility Investigation (PFMI). The investigations were specifically developed to increase our understanding of the formation of bubbles and voids in liquid metals. In both cases the teamwork concept inherent in the MSG design demonstrated that enhanced scientific return is possible when the crew and scientists can easily interact. The crew worked closely with ground-based scientists through real-time data and video links to assemble and operate scientific hardware. Scientists were then able to adjust the experiment processes based on the results of observations as they occurred.

In addition, the MSG integration team worked with the European Space Agency (ESA) to integrate four Belgian experiments into the MSG facility. Experiment apparatus for each investigation was flown on a Russian Progress resupply ship to the *ISS* for on-orbit operation. The Combustion Synthesis under Microgravity Conditions (COSMIC) experiment examined the relationships between the various phenomena that occur during combustion and the formation of microstructures in metal-matrix compounds. This research has significant

relevance to the synthesis of advanced materials, such as intermetallics, ceramics, and metal-matrix composites. The Diffusion Coefficients in Crude Oil (DCCO) investigation was concerned with the diffusion coefficients of chemicals present in crude oil. The Study of Aggregation Mechanism and Kinetics of Nanoslabs (NANOSLAB) experiment sought to understand the effects of convection and sedimentation during bulk-zeolite formation. The Protein Crystal Growth Monitoring by Digital Holographic Microscope (PromISS) experiment used a digital holographic microscope coupled with a laser source to gather data at different focal points in protein crystals during crystal growth. Researchers were also concerned with the concentration of proteins in the solution around the growing crystal.

Additional vibration isolation capability, originally scheduled for installation into MSG during FY 2002, was delayed until FY 2003 because of an electronic amplifier failure that occurred during testing. Once delivered to the *ISS*, the Glovebox Integrated Microgravity Technology (g-LIMIT) unit will provide an isolated, stable platform for vibration-sensitive experiments inside the MSG.

Workshop sessions dedicated to MSG investigations were conducted at the AIAA Conferences on *ISS* Utilization at KSC in Houston, TX, during FY 2002. Interest remains high in future use of the MSG. Based on the unqualified success of the unit in its initial operations, a further series of experiments, sponsored by both NASA and the ESA, are planned for FY 2003. These new experiments will extend the use of the unit to additional disciplines including biotechnology, combustion, and fluid science, thereby promoting the development of this interactive approach to *ISS* science.

Materials Science

The year 2002 was a year of firsts for the materials science discipline. The first two materials science investigations were performed onboard the *ISS*, and a key milestone was reached in developing the Materials Science Research Rack (MSRR–1). The MSRR–1 rack will be the first research facility dedicated to conducting materials science in space. These and other accomplishments continue to advance the goals of the materials science program: to understand fundamental relationships among the processing, structures, and properties of materials in the absence of significant gravity effects.

First Materials Science Experiments Conducted on *ISS*

Scientists on Earth collaborated with crewmembers to conduct the first two materials science investigations on the *ISS*: SUBSA and PFMI. Both investigations were conducted in the MSG environment. A complete series of successful SUBSA experiment runs yielded information that will increase our understanding of the solidification process used to produce semiconductors on Earth. Data will also be used as a benchmark to calibrate additional ground-based research.

A second materials science investigation, PFMI, was initiated, and five runs were successfully completed. This experiment, to be continued in FY 2003, will provide information on the basic physics governing bubble formation and movement in molten materials. Data from this experiment can be critical to the success of future materials processing by shedding light on the formation of bubbles, an event that can cause defects in materials during the solidification process.

Hardware for a third materials science investigation, Coarsening in Solid Liquid Mixtures-2 (CSLM–2) was delivered to the *ISS*, in preparation for scientific research in FY 2003.

During Expedition 5, Peggy Whitson completes the installation of the MSG in the Destiny Module and prepares it for the first series of experiments.

Belgian Soyuz 5 Flight Engineer Frank DeWinne, of ESA, works with experiments mounted to the floor of the Glovebox working area on the *ISS*. Once assembly is complete, the ports can be sealed to prevent any possible hazards from escaping into the crew area in the module.

Dr. Sharon Cobb shows how a cylindrical sample will be inserted into the rack's furnace for processing aboard the *ISS*.

This investigation is the first materials science experiment to fly on *ISS* that has undergone the full NRA review process.

First Dedicated *ISS* Materials Science Facility

In the future, on-orbit materials science research will be conducted in the MSRR–1, the first *ISS* rack-level facility designed primarily for research in materials science. Ranked among the highest science priorities by the Research Maximization and Prioritization Task Force, the MSRR–1 project successfully completed two milestones: the Integrated Payload CDR and the Phase 2 Flight Safety Review. The facility is currently on schedule to begin manufacturing and assembly in 2003. After delivery to the *ISS* in 2005, the MSRR–1 facility will accommodate investigations in basic and applied research in fields such as solidification of metals and alloys, thermophysical properties, crystal growth of semiconductor materials, and ceramics and glasses.

Development of the Quench Model Insert (QMI) is also on schedule. This unique furnace will be inserted in the European-designed Material Science Laboratory (MSL) experiment module within the MSSR–1. The QMI has been designed for processing metals and alloys using a technique known as directional solidification. This insert will allow researchers to process samples at temperatures up to 1,400 °C, then rapidly freeze the sample at the solid/liquid interface, where much of the interesting activity takes place during directional solidification.

Materials Science Research Initiatives

During FY 2002 final preparations were completed for integrating the Mechanics of Granular Materials (MGM) investigation on STS–107. Actual launch of this flight was delayed until early 2003. This mission ended tragically in the loss of the crew and Space Shuttle *Columbia*. While the MGM experiment specimens were lost in the accident, NASA and its researchers continue to evaluate the scientific data that was downlinked during the mission to experiment teams on Earth.

Peer review of a new science concept, Levitation Observation of Dendrite Evolution in Steel Ternary Alloy Rapid Solidification (LODESTARS) was completed. This investigation will research the microstructures formed during the rapid solidification of a molten metal alloy. In order to avoid contamination of the undercooled melt, a containerless electromagnetic levitation (EML) processing technique will be used. The low-gravity environment of the *ISS* will provide researchers a better understanding of the influence of convection on phase changes and the evolution of microstructures.

MSFC's Materials Science discipline continues to pursue research initiatives that relate to fundamental and unresolved issues of new materials. The following three initiatives have been identified as key areas of research focus. They are closely aligned with NASA's mission to support long-term exploration of the universe and beyond.

- Advanced Space Propulsion. Significant accomplishments in materials technology are required to extend space exploration to the outer reaches of the solar system and beyond.
- Space Radiation Shielding. Additional materials research is needed to protect both astronauts and the spacecraft from the harmful and potentially lethal effects of radiation encountered in long-duration missions.
- In-Space Fabrication for Exploration. Long-distance exploration will require mature technologies to transform space resources into manufactured parts and space hardware that cannot be launched due to cost, size, or structural constraints.

The materials science discipline continues to realign its research focus to meet NASA's commitment to long-duration, long-distance space exploration. In doing so, the program will address these special themes as identified in current and future NRAs.

Metrics

FY 2002 Microgravity Science and Applications Metrics

Biotechnology

Provide flight opportunities for peer-reviewed investigators to gather data on macromolecular crystal growth.

The Associate Investigator program was set up in FY 2001 and continued to provide a means for researchers in the external scientific community to obtain rapid access to microgravity for structural biology investigations. Throughout FY 2002, the Program announced flight opportunities to the scientific community and assisted external researchers throughout the flight process. Project scientists helped associate investigators through the process beginning with making application and flight preparation, then assisting through launch, and finally to postflight retrieval of samples. Associate Investigators provided 52 biological crystallization experiments that were sent to *ISS* on Assembly Flight 8A (STS–110); 32 experiments on UF1 (STS–108); and 14 experiments on UF2 (STS–111).

Beginning in early FY 2002, NISB was established at the HWMI. In collaboration with the Macromolecular Biotechnology Associate Investigator Program, the Institute began notifying the structural biology community of research opportunities and began conducting independent peer-review of all structural biology/crystal growth samples that will fly in NASA's Physical Sciences Division within the OBPR. NISB will also assist researchers by guiding them through the entire process of flying experiments on the *ISS*; provide preflight and postflight characterization of flight samples including detailed comparison of crystal quality between space-grown and Earth-grown crystals; and help investigators secure timely access to the Stanford Synchrotron Research Laboratory at Stanford University.

Expand student and teacher involvement in the biological crystallization education program to 12 states.

By the close of FY 2002, over 445 students and 264 teachers from over 235 schools in 11 states had participated in Flight Program workshops and launch activities. Over 1135 teachers from more than 390 schools across 40 states including Puerto Rico and Washington, DC, were involved with the Program through workshops. It is estimated that these teachers involved 35,000 to 55,000 students in related classroom and laboratory activities.

Additionally, the program has received extensive coverage from the following media:

Television: Over 69 pieces aired on seven major networks and cable channels in 21 states, with CNN and National Geographic Television having nationwide coverage.

Radio: Over four pieces aired on 85 stations of Alabama Public Radio Network, one California station, Florida Public Radio, and the well-known Osgood Radio Files on CBS radio.

Newspapers: Over 38 articles in local newspapers in ten states.

Magazines: Over four articles in the recognized magazines Aviation Week and Space Technology, Astronomy Magazine, People Magazine, and The Scientist.

World Wide Web sites: Over four articles (excluding NASA sites) on the following space and science Web sites: Astronomy.com, ScienceDaily.com, Space.com, and UPN Online

Support the release of the NRA to select peer-reviewed research in molecular biotechnology.

The OBPR issued the release of NRA-01-OBPR-08 in December 2001. Working in collaboration with the OBPR Enterprise Scientist, Biotechnology discipline managers, scientists, and members of the science team made recommendations and provided draft language for research information for inclusion in announcement.

Microgravity Science Glovebox

Deliver the MSG Facility to ISS for flight.

Launched to the *ISS* on Assembly Flight UF2 (STS–111) in June 2002, the MSG was installed in the Destiny module and was successfully used to conduct a series of science investigations.

Deliver the vibration isolation g-LIMIT to ISS for flight.

Because of an electronic amplifier failure during testing, delivery of the g-LIMIT unit to the *ISS* was delayed. Testing is now complete, and the unit is awaiting manifest on a future flight.

Integrate four experiments into MSG for flight.

A total of six experiments, including two NASA materials science investigations, SUBSA and PFMI, were integrated into the MSG facility and successfully

Metrics

FY 2002 Microgravity Science and Applications Metrics — continued

Microgravity Science Glovebox—continued

conducted operations. In addition, four Belgian experiments made use of the protected MSG environment for research on the *ISS*. In conjunction with the ESA, the following investigations were conducted in the facility: COSMIC, DCCO, NANOSLAB, and PromISS.

Hold a postflight workshop for potential MSG investigators after the facility becomes operational.

Workshop sessions dedicated to MSG investigations were conducted at the AIAA Conference on *ISS* Utilization in Houston, TX, and KSC during FY 2002. These sessions were chaired by MSFC personnel.

Materials Science

Deliver and operate two fundamental materials science investigations in the MSG on the ISS.

The Materials Science discipline delivered and operated two investigations in the MSG: SUBSA and PFMI. All planned SUBSA runs and the initial PFMI runs were completed during FY 2002.

Fly on STS–107 and retrieve data from the MGM Experiment.

The launch of STS–107 flight carrying the MGM experiment was delayed until early 2003. While a significant amount of telemetry was downlinked, the mission ended with the tragic loss of the crew and Space Shuttle *Columbia*.

Complete one peer review of a new investigation science concept.

Peer review of a new investigation science concept was completed. The concept, titled "Flight Planning for the *International Space Station*—Levitation Observation of Dendrite Evolution in Steel Ternary Alloy Rapid Solidification (LODESTARS)," was submitted by Dr. Merton C. Flemings, Massachusetts Institute of Technology; Dr. Douglas M. Matson, Tufts University; Dr. Wolfgang Löser, IFW-Dresden; Dr. Robert Hyers, NASA-MSFC; and Dr. Jan Rogers, NASA-MSFC.

Identify and explore the fundamental and unresolved issues in at least one new materials science field.

Materials science discipline managers and scientists worked with NASA's OBPR Enterprise to identify In-Space Fabrication for Exploration and Advanced Space Propulsion as special focus themes. These themes were presented in the NRA released in December 2002, NRA-02-OBPR-03 Research Opportunities in Physical Science.

Support the release of the annual NRA to select peer-reviewed research in materials science.

Working in collaboration with NASA's OBPR Enterprise, materials science discipline managers and scientists made recommendations and provided draft language for inclusion in NRA-01-OBPR-08, Research Opportunities in Physical Sciences, which was released in December 2001.

Space Optics Manufacturing Technology

Optics is an essential part of NASA's missions. The development of lightweight optics and optical systems is key to the reduction of launch costs. The Space Optics Manufacturing Technology Center (SOMTC) is continuing the development of new technologies for the production of large-aperture, lightweight optics for space-based systems.

James Webb Space Telescope

The history of astronomical optical systems has shown a continuous drive towards lighter optical elements. The primary mirror in the ground-based Hale telescope at Mt. Palomar—using 1947 technology—weighs roughly 550 kg/m^2. The Hubble Space Telescope primary—using 1980s technology—weighs about 150 kg/m^2. MSFC is supporting Goddard Space Flight Center (GSFC) by leading the development of ultralight optics for the James Webb Space Telescope (JWST). The design goal for the JWST mirror, scheduled to fly around 2009, is 15 kg/m^2. MSFC completed the management of two major mirror development programs: The New Mirror System Demonstrator (NMSD) and the Advanced Mirror System Demonstrator (AMSD). Four different mirror technologies ranging from 1.6 m to 2.0 m in diameter were developed that meet the JWST weight goal. The AMSD program was unique in that funding was provided by multiple agencies, including NASA and the United States Air Force.

MSFC's groundwork and infrastructure support will enable the testing of the optical components of the James Webb Space Telescope (JWST).

Constellation X

SOMTC is a key resource in mirror technology support to GSFC on the next generation x-ray mission called Constellation X. This mission will be a follow-on to the recently launched Chandra X-ray Observatory. Constellation X is planned for new mission start around 2005 and will require lighter-weight x-ray optics than previously developed.

The Constellation X program has decided to concentrate development efforts on segmented x-ray reflectors and hence no longer supports full-shell replicated mirror development. SOMTC supports segmented mirror development for Constellation X by segmented mirror mandrel procurement and metrology; cleaning, coating, and metrology of full-cylinder mandrels for segmented reflector development; and testing of prototype x-ray mirror modules. Testing will be in the straylight facility (100-m tunnel) initially, and later in the X-ray Calibration Facility (XRCF).

Extreme Universe Space Observatory

SOMTC conducts research efforts in large-area fresnel lens development. Fresnel lenses consist of concentric annular rings with a specific prescribed shape that allows all rings to act as a single lens with a common focus. The rings all lie in a common plane, making a fresnel lens extremely flat as compared to a common refractive lens. Fresnel lens research efforts contribute to three different concepts currently being studied for use in detecting high-energy gamma rays and their interaction with the upper atmosphere. Extreme Universe Space Observatory (EUSO) will use such fresnel lenses to examine the interaction between the Earth's atmosphere and extremely energetic cosmic rays.

Research

Areas of research expertise at SOMTC include: Optical physics, photonics, electro-optics, laser systems, diamond turning and precision engineering of optical surfaces, test and analysis of optical system stray light performance, test and analysis of x-ray optics, and unique and innovative methods for optical fabrication, testing, and coating.

Research efforts in the area of laser physics led to the development of a solid-state Rodamine-impregnated polymer used as a lasing gain medium. A master oscillator and light amplifier were demonstrated using this new material. Applications for use range from power beaming and energy transfer to new methods for in-space propulsion.

Metrology

SOMTC is developing a center for calibration and metrology of large optical components and systems. The facilities and expertise of SOMTC include optical fabrication, optical metrology, stray light scattering, and surface morphology. These are being applied to a number of NASA, DOD, Department of Energy, National Oceanographic and Atmospheric Administration (NOAA), industry, and academic needs.

A EUSO development fresnel lens was cut on the Moore M40 diamond turning machine.

Metrics

FY 2002 Space Optics Manufacturing Technology Metrics

Implement a control system for the global radius of curvature on a segmented ground-based telescope.

This objective was completed in FY 2002 as the Global Radius of Curvature Estimation and Control System was installed and verified on the Hobby-Eberly Telescope. The results of this work were published in the proceedings of the International Society for Optical Engineering. Also, a Disclosure of Invention and New Technology was filed for this innovation.

Complete a 0.25-m diameter x-ray mandrel and produce an electroformed shell under 0.25-mm thick.

The mandrel halves were diamond turned and plated, and are scheduled for final diamond turning. Work will continue on the shell forming.

Test two additional mirror technologies in the XRCF in support of JWST.

JWST was supported by SOMTC having a) lead the mirror technology development effort via the AMSD and NMSD contracts, b) prepared and validated XRCF infrastructure and procedures for testing AMSD and eventually the JWST primary mirror segments, c) served as a voting member on the Source Evaluation Board which assisted in the award of a prime contract without protest, and d) been designated the JWST optical components lead responsible for insight/oversight on the JWST primary, secondary, and tertiary mirror fabrication and test.

Produce a diamond turned double-sided Fresnel lens on a curved substrate.

A 1-m diameter development meniscus, double-sided Fresnel lens was cut on the Moore M40 diamond turning machine for EUSO. The polycarbonate lens was tested and shown to perform as designed.

Install and demonstrate the precision optical generator in the optical fabrication area.

Installation and assembly of the precision optical generator has proceeded more slowly this year than originally anticipated. This has been due to availability or lack of personnel and funds. It is currently anticipated that the machine will be operating by the end of FY 2003.

Implement an advanced mirror algorithm simulation using a large cluster computer.

Significant progress was made in implementing an advanced mirror control algorithm on a large cluster computer, though the objective has not yet been completed. Under MSFC's Advanced Computing Technology initiative and supported by the NASA Faculty Fellowship Program, a genetic algorithm (GA) was successfully applied to the phase retrieval problem for a segmented mirror. The concept of applying a GA to the phase retrieval problem was proved out on a desktop PC in the Matlab environment. In FY 2003, work will proceed to parallelize the algorithm for implementation on the cluster computer.

Expand the size of the current ion polishing capability.

This capability was not continued. The ion polishing/milling facility was closed for reallocation of resources.

Develop rugged laser sources of less than 0.01-m^3 volume and large-gain, medium area for use in sourcing microgravity imaging and diagnostic science.

A Center Director's Discretionary Fund (CDDF) was awarded to support procurement of components and hardware. Laboratory areas and facility requirements at the National Space Science and Technology Center (NSSTC) have been identified for assembling a laser prototype.

Perform experimental characterization of a bandpass modulation element using nonmechanical means for implementing phase modulation.

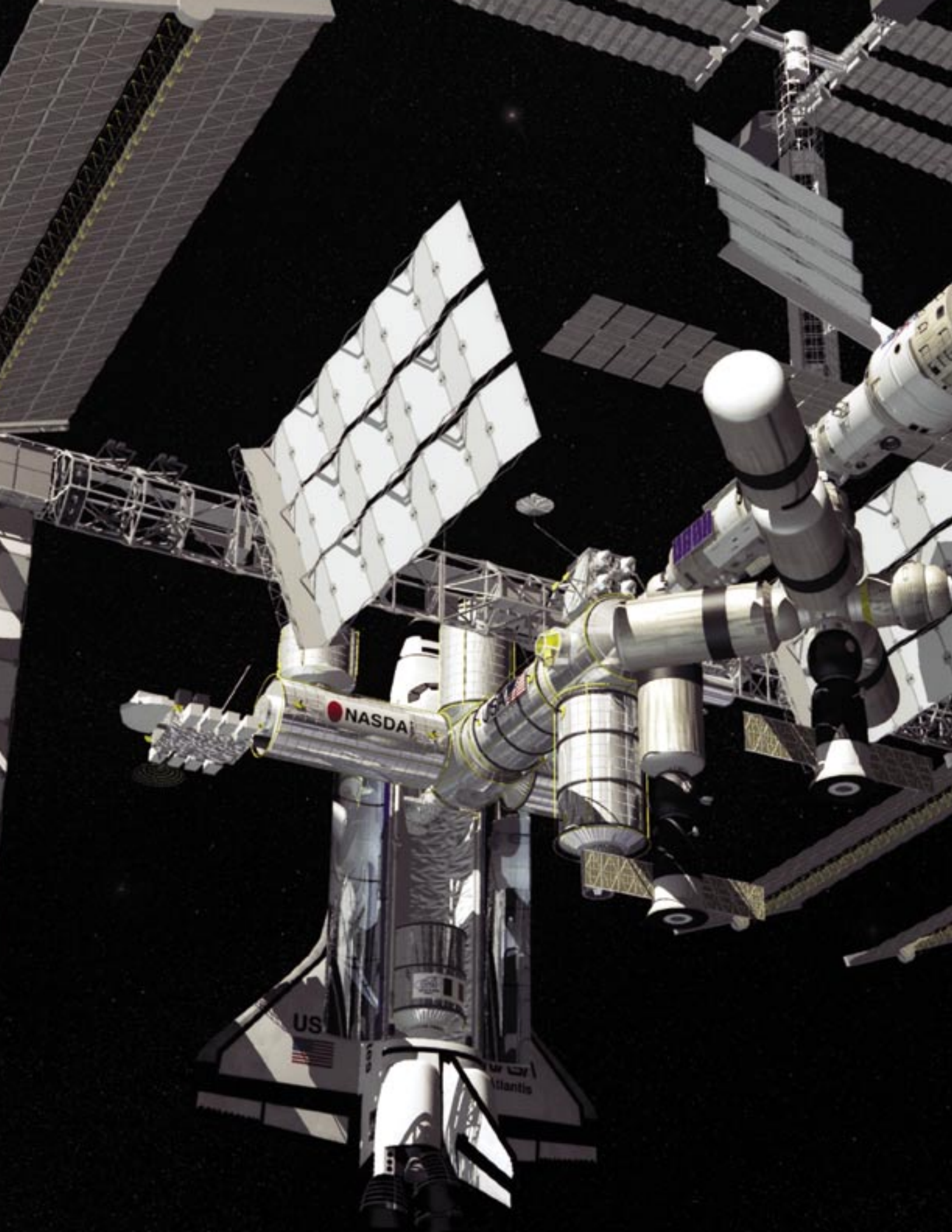
This would have been a continuation of a technology development effort, but it was never funded by the programs of Code R.

Reduce the optical figure in the normal incidence electroformed optics by a factor of two.

The funding for the Gossamer NRA has been denied and work on the replicated optic has been reduced.

Establish at least one process to monitor and evaluate customer satisfaction.

The tracking program was implemented and initially discovered communication issues between the SOMTC and some of its customers. These issues were quickly identified and corrected resulting in a high degree of customer satisfaction.


NASDA

Other Programmatic Assignments

The *International Space Station*

The *ISS* is a U.S.-led international partnership program to build and operate a unique world-class orbiting laboratory, free from the effects of gravity. This space laboratory is conducting long-term scientific research and technology development for the benefit of life on Earth and the continued exploration and development of space.

In FY 2002, MSFC supported the *ISS* Program through task agreements with the *ISS* Program Office at the NASA Johnson Space Center (JSC). MSFC played a vital role in building, operating, and utilizing the *ISS* for NASA through the performance of these tasks.

Specifically, MSFC responsibilities included the continued development of regenerative life support systems for the *ISS* crew and the research animals. Collectively, this is called the Environmental Control and Life Support System (ECLSS). The MSFC-managed portions of the ECLSS include the development of the Water Recovery System (WRS) to recycle wastewater (including urine); produce, store, and distribute potable drinking water; and use of the WRS recycled water to produce oxygen for the crew via the Oxygen Generation System (OGS). In FY 2002, the design of the WRS and OGS were advanced through the CDR stage. In addition, several orbital replacement units were completed in FY 2002, and plans were finalized for rack integration activities starting in FY 2003.

MSFC provided technical management oversight of Nodes 2 and 3, which are being provided by Alenia Spazio under contract to the Agenzia Spaziale Italiana (ASI, the Italian Space Agency) through a bartered ESA to NASA agreement. The purpose of Nodes 2 and 3 are to act as the connecting elements for other station elements including the space station system utilities, and to provide a safe pressurized passageway between other international elements. Node 2 was near completion in FY 2002, with integration and system testing scheduled for 2003. On Node 3, Design Review 2 was completed, allowing for the start of module integration.

MSFC continues to be a leader in the development of payload facilities for the *ISS*. The innovative Expedite the Processing of Experiments to Space Station (EXPRESS) rack provides simple, standard interfaces to accommodate drawer-level, locker, and modular-type payloads from all science disciplines. The EXPRESS rack concept provides for a simple and shortened integration cycle. By leveraging off of a common avionics design, MSFC has been able to develop derivative payload facilities for other NASA customers at a reduced cost for the *ISS*. Future *ISS* maintenance costs will be reduced through the ability to share spare replacement units and repair depots on the common avionics.

MSFC continued to provide the Multipurpose Logistics Module (MPLM), which serves as the *ISS* moving van. The MPLM, loaded with laboratory racks that are filled with experiments, supplies, and equipment, travels in the Space Shuttle payload bay to dock via the robotic arm to the *ISS*. There, the crew unloads and reloads the MPLM to start the process all over again, giving a quick turn-around to

MPLM Flight Module 2 (Rafaello) in *Endeavour*'s payload bay during the STS–108/UF–1 mission.

Payload Operations Center.

Illustration of *ISS* at assembly complete.

Metrics

FY 2002 *International Space Station* Metrics

Generate preincrement plans that utilize at least 90 percent of the resources assigned to utilization.

Preincrement plans utilized all available resources necessary to accomplish increment science objectives. A payload reserves policy was negotiated with the *ISS* program to maximize the use of new resources that come available after increment start.

Maintain performance metrics to measure the ability of the Payload Operations Center to meet the requirements of the ISS Utilization Program.

Specific metrics were developed and are maintained on a continual basis. Additionally, the metrics are used as performance measures in contract evaluation.

Perform resource tracking to ensure that utilization resources are allocated in real-time according to program baselined documentation.

Resource utilization is tracked daily to ensure the proper implementation of baselined plans. These numbers are reconciled weekly with the *ISS* program office and international partners.

Launch of MPLM Rafaello UF–1 mission, in 1st quarter FY 2002.

MPLM Rafaello (Flight Module 2) successfully flew as part of the STS–108/UF–1 mission in December 2001.

support the *ISS* mission schedule. ASI/Alenia provided three MPLMs. MSFC continues to be responsible for the engineering oversight, sustaining engineering, and overall project management of the MPLMs. Two MPLMs flew on the Space Shuttle to the *ISS* in FY 2002, STS–108/UF–1 in December 2001, and STS–111/UF–2 in June 2002.

MSFC provided integration support of the lightweight multipurpose experiment support structure (MPESS) carrier (LMC). The LMC flew for the first time on STS–108/UF–1 in December 2001. It flies in the Orbiter's Bay 13, where no carrier has flown before.

MSFC's Testing, Manufacturing, and Support Team continues to provide technical expertise to *ISS* design and development teams. Various areas of testing, including structural, dynamic, environmental, electromagnetic, and acoustics, were supported.

MSFC continues to be responsible for the management, integration, and execution of payload operations and utilization activities onboard the *ISS*. The Payload Operations Center, located at MSFC, is the *ISS* Program focal point for payload operations. MSFC controllers staff the facility and interact with the worldwide scientific research community to plan and conduct payload operations on board the *ISS*. MSFC was also responsible for the integrated payload training for the increment crews.

Providing the technology infrastructure for payload operations is also part of MSFC's charter. The command and control systems for operating vehicle systems related to payloads are implemented in the Huntsville Operations Support Center, as well as the data distribution systems to provide command and control connectivity to the international partner payload facilities, and remote U.S. Principal Investigators. Unique payload planning and support systems are also part of this infrastructure, and, even at the remote locations, MSFC is providing the Telescience Resource Kit to give remote users a ready-made, low-cost solution for processing and displaying their science data.

Node 2 during integration and systems testing.

Metrics

FY 2002 *International Space Station* Metrics—continued

Launch of MPLM Leonardo UF–2 mission, in 3rd quarter FY 2002.

MPLM Leonardo (Flight Module 1) was integrated and successfully flew as part of the STS–111/UF–2 mission launched June 5, 2002.

Conduct monthly payload operation status reviews with MSFC management.

Reviews continue to be completed as planned.

Conduct quarterly payload operation status reviews with program office management.

Quarterly reviews continue to be held as planned.

Maintain the payload operations budget within five percent of the mark.

Were within less than five percent of the mark throughout July. Were within ten percent of the mark due to uncosted procurements. Arrangements were made to roll the necessary funds into FY 2003.

Complete and certify the cargo element for the UF–1 LMC mission 1st quarter FY 2002.

Completed and delivered to Kennedy Space Center (KSC) in July 2001. Turned over to KSC in October 2001. Hardware flew as part of the STS–108/UF–1 mission in December 2001.

Complete and certify the Service Module Debris Shield cargo element for the UF–2 sidewall carrier mission, 2nd quarter FY 2002.

Completed and delivered to KSC in January 2002. Hardware flew as part of the STS–111/UF–2 mission launched in June 2002.

Complete integration design review for the Ranger Mission, 3rd quarter FY 2002.

The Payload Carriers Program suspended this work in 2002 at the direction of the *ISS* Program.

Complete and deliver the UF–4 flight support equipment, 3rd quarter FY 2002.

Acceptance Review was completed in March 2002. Action items from this review were completed by end of 2002, and flight support equipment was delivered.

Node 2 integration and systems testing completed, 4th quarter FY 2002.

Node 2 Integration and Systems testing completion is now scheduled for the 2nd Quarter FY 2003, based on the *ISS* Program baseline.

Node 3 design review number two completed, 4th quarter FY 2002.

Node 3 Design Review 2 was completed on schedule.

Participate in the Research Program Payload Program Manager reviews and support the end of the year review with payload operation metrics.

Payload Program Manager reviews were fully supported.

Vapor Compression Distillation Flight Experiment, which will be used as an engineering precursor to the final urine processor assembly, to fly on STS–107, scheduled for 4th quarter FY 2002.

Launch rescheduled for 2003 due to Shuttle Program decision.

Subsystem drawings for WRS, OGS, and power supply module completed, 4th quarter FY 2002.

All Urine Processor Assembly, Water Processor Assembly, and Oxygen Generation Assembly assembly-level drawings completed. Power Supply Module drawings behind plan but not driving final delivery schedule.

WRS/OGS CDR, 3rd quarter FY 2002.

WRS/OGS CDR was completed.

Support the implementation of voice over the Internet to drastically reduce the cost of payload operation voice communication requirements.

The Operational Readiness Review (ORR) was held on August 22, 2002. System is operational after settling a few issues that resulted from the ORR.

Generate preincrement plans that utilize all the mid-deck lockers assigned to utilization.

All mid-deck locker space is fully utilized and a candidate list of utilization items is maintained if additional volume is available.

Metrics

FY 2002 Advanced Projects Metrics

Provide NASA HQ with technical and program management support as needed for HTCI activities.

Activities funded under HTCI provided a foundation for future work under THREADS.

Provide support to NASA HQ with preliminary definition of potential technology flight experiments on the ISS for SSP, propellant depots, or other flight project areas as requested.

Personnel within the Advanced Projects Office supported each of the specified activities as requested.

Provide NASA HQ with technical and program management support as needed for the international forum activities.

Representatives from the Advanced Projects Office participated in International forums pertaining to SSP.

FY 2002 Chandra Metrics

A commitment for viewing efficiency greater than 50 percent average per year, with a goal of 60 percent.

Over the previous 12 months the viewing efficiency has exceeded both the goal and requirement.

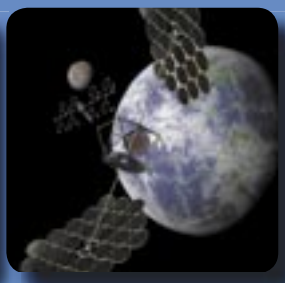
Loss due to interruption of program due to ground error/procedures less than 5 percent per year.

Over the previous 12 months the data loss from all causes has run well within the requirement.

Data loss from observation to delivery to user less than five percent.

Over the previous 12 months the Observing time lost due to ground error is well within the five percent requirement.

New space industries could result from HTCI and THREADS activities.



SSP concept for energy transfer to Earth.

Chandra X-ray Observatory.

Advanced Projects

The Advanced Projects Office provided support to the development of future projects through the Human Exploration and Development of Space Technology Commercialization Initiative (HTCI), Technology for Human and Robotic Exploration And Development of Space (THREADS), and Space Solar Power (SSP) activities. These activities included analysis of systems concepts, technology development, and demonstrations, to identify viable approaches to future space development, exploration, and SSP for Earth, planetary surfaces, and space applications. Products enabled NASA management to make informed decisions on a portfolio of space development and exploration concepts, including SSP technology investments.

Chandra

MSFC manages the operation of the MSFC-developed Chandra X-ray Observatory through the Operations Control Center and the Chandra X-ray Center at the Smithsonian Astrophysical Observatory in Cambridge, MA. Program goals are to determine the nature of celestial objects from normal stars to quasars, understand the nature of physical processes that take place in and between astronomical objects, and understand the history and evolution of the universe. These goals will be accomplished by extending the range of astrophysical observations significantly beyond that of previous x-ray observatories through increases in sensitivity and resolution.

National Space Science and Technology Center

The NSSTC, headquartered in Huntsville, AL, is a collaborative research and education institution that provides an environment for research in selected key scientific disciplines. It consists of researchers and resources from government, academia, and industry collaborating in an environment that enables cutting-edge basic and applied research and fosters educa-tion of the next generation of scientists and engineers. It is a unique blending of people, facilities, and tools to encourage advances in earth science, space science, materials science, biotechnology, optics and energy technology, space propulsion, and information technology.

The research performed by the NSSTC covers the range of maturity from pure science to technology development to mission operations and data analysis. In appropriate disciplines, laboratory experiments, sounding rockets, balloons, and aircraft are used as platforms for the investigations being pursued. Where appropriate, experiments are flown on manned and unmanned spacecraft. Educational activities include both graduate level and undergraduate level for students at the partnering academic institutions, as well as outreach and teacher training for K–12. The formal NSSTC partnership is between NASA/MSFC and the State of Alabama. The State is represented by the Space Science and Technology Alliance, which is comprised of the seven research universities in the state. The NSSTC academic partners include the University of Alabama, University of Alabama in Huntsville, University of Alabama at Birmingham, Auburn University, Alabama A&M University, the University of South Alabama, and Tuskegee University.

The NSSTC is growing the "national" aspect of its name through the affiliate process. This process provides an avenue for universities and industries to establish formal working relationships with the NSSTC without specifying the detailed work effort. As the specific work opportunity is identified, subagreements are developed that detail the statement of work, period of performance, estimated cost, and deliverables. The goal of the NSSTC is to aid our customers in establishing these working relationships and to make them as seamless as possible.

The National Space Science and Technology Center.

Metrics

FY 2002 National Space Science and Technology Metrics

Complete benchmarking of the NSSTC among peer organizations and develop an appropriate business model, including overhead rate and cost-recovery structure.

Benchmarking was performed against three peer organizations to evaluate business practices. The benchmarking activity provided best practices and influenced the overhead rate development process currently in use at the NSSTC. The NSSTC business model has been structured to ensure all costs are identified and the established rates recover these costs.

Complete occupancy of annex building.

Personnel assigned to the new 80,000-square-foot annex completed their move in September 2002. The laboratories are scheduled for outfitting in FY 2003.

Establish formal alliances with three industry affiliates and five universities outside the state of Alabama.

Formal alliances were established with four companies (Teledyne Brown Engineering, Radiance Technologies, Inc., Global Environmental Management, and United Applied Technologies), four universities (Vanderbilt University, Georgia Institute of Technology, University of Illinois, and University of Denver Research Institute), and one nonprofit company (Universities Space Research Association). Instructional guidelines were developed for potential industry affiliates in order to expedite the formal request process.

Global Hydrology and Climate Center

The Global Hydrology and Climate Center (GHCC) is a joint venture between the Earth Science Department of MSFC, the University of Alabama in Huntsville, and the Universities Space Research Association (USRA). GHCC, which is located at the NSSTC, engages in Earth science research, education, and technology infusion of Earth sciences. The Earth Science Department focuses on using advanced technology to observe and understand the global climate system, and applies this knowledge toward understanding basic questions about the Earth system, operational meteorology, urban planning, agriculture, and water resource management. Areas of emphasis include observations of precipitation, lightning, multispectral remote sensing of the Earth's surface, the global hydrologic and energy cycles, and numerical modeling of weather and climate.

Significant advances have recently been made by GHCC scientists in quantifying changes to oceanic evaporation, precipitation, and other components of the global hydrologic cycle. Using a wide range of satellite-based observations, cloud process models, and climate model integrations, research has helped improve our understanding of how physical processes involving clouds, water vapor, soil moisture, and snow cover act to constrain or amplify climate variability.

The continued acquisition of global lightning data from the Lightning Imaging Sensor (LIS) onboard the Tropical Rainfall Measurement Mission (TRMM) has greatly contributed to an understanding of the relationship between lightning flash rate and severe storm onset, as well as volume of storm precipitation. Advanced lightning measurement techniques continue to be pursued via a mission for continuous lightning mapping from geostationary orbit.

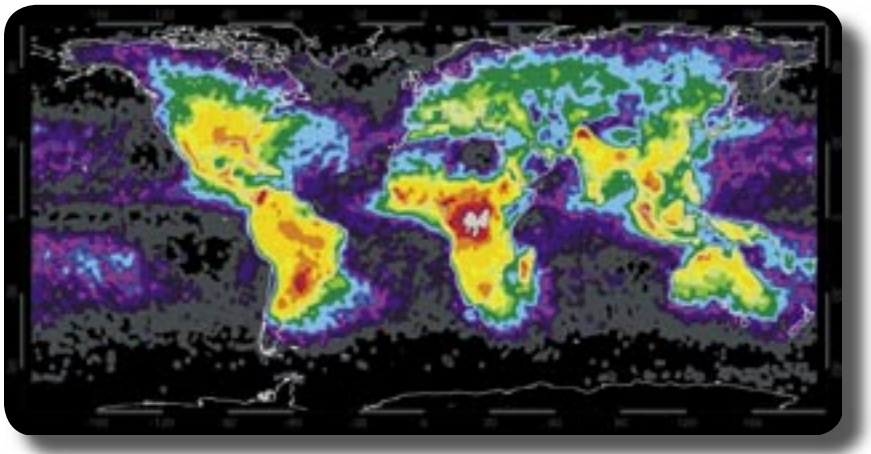
Additional lightning data was gathered utilizing an Uninhabited Aerial Vehicle (UAV) as the observing platform in the ALTUS Cumulus Electrification Study (ACES) project in the summer of 2002 in Florida. This highly successful field program provided valuable data in studying severe storm processes, as well as successfully demonstrating the UAV technology.

A regional forecast improvement laboratory integrating space technology with ground-based data sets and numerical models has been set up as a cooperative venture with universities as well as the operational forecast offices of the National Weather Service (NWS). This effort is accelerating the use of NASA's Earth Observing System (EOS) data to improve regional short-term weather prediction and warning within the NWS and is part of NASA's contribution to the U.S. Weather Research Program—see http://www.uswrp.org.

Other regional activities include evaluating the interannual climate variability of the southeast U.S. and determining implications on key economic sectors. Also addressed were such regional scientific issues as regional sources and sinks for tropospheric ozone and its transport, regional air chemistry and air quality, and water management questions. We pursued new formalisms of incorporating urban heat island measurements into predictive meteorological and air quality models as well as the use of intelligent system capabilities to aid state and local regional planning decision makers in dealing with societal issues. Other areas of expertise include developing improved satellite retrieval techniques to measure and monitor atmospheric aerosol concentration, its transport, and its influence on radiative properties of clouds.

The GHCC also performed unique archaeological studies using remote sensing for studying impacts of climate variability on pre-Columbian American settlement patterns, contributing to Earth Science Enterprise global land-use classification, and to support the NASA Memorandum of Understanding with Central America for technology transfer in the use of remote sensing in land-use change research there.

Other areas supported by the Earth Science community within the GHCC included the development of improved satellite retrieval techniques to measure and monitor atmospheric state variables, aerosol concentration, their transport and influence on radiative properties of clouds, and validation studies for various EOS instruments. As a research support function, GHCC continued developing its capabilities through component data information systems for lightning and microwave satellite measurements and the efficient accessibility by the science community.



Map of annual lightning flash rate.

Metrics

FY 2002 Global Hydrology and Climate Center Metrics

Continue archival and distribution of global temperature measurement database from orbiting microwave sounding units.

Timely monthly updates of global temperatures to the research community from all three NOAA satellites carrying microwave sounding units (MSUs) were provided online.

Complete initial calibration and validation of the new Special Sensor Microwave Imager/Sounder (SSMIS) and demonstrate scientific usefulness.

The launch of the SSMIS sensor has been delayed until early 2003.

Analyze lightning and passive microwave data collected by airborne sensors during the CAMEX-4 hurricane experiment. These data along with that collected by all CAMEX-4 instruments will be cataloged and archived by the Global Hydrology Resource Center (GHRC) by the end of FY 2002.

The CAMEX-4 data system and archive maintains an extensive listing and documentation of all CAMEX-4 data sets received from the individual instrument principal investigators. All data sets received to date are available for distribution through the GHRC archive and are listed on the EOS Data Gateway and the NASA's Global Change Master Directory. Data sets, field reports, and science presentations may be viewed at CAMEX-4 Web site—http://camex.msfc.nasa.gov.

Continue successful operation of the LIS onboard the TRMM.

LIS has continued to provide excellent, high quality data. No problems have been experienced. The user base has expanded to well over 100 users from more than a dozen countries.

Extend diagnostics of tropical energy and water cycle to quantify water vapor and cloudiness interactions with radiation during El Niño Souther Oscillation (ENSO) events.

Differences were discovered and quantified between radar and radiometric estimates of rainfall through an analysis of data from TRMM sensors. These results have become a valuable constraint in interpreting variations in cloud water and radiative fluxes during El Niño and La Niña climate anomalies.

Develop an initial assessment of the ability of current climate models to simulate ENSO-related climate perturbations vis-à-vis EOS satellite observations.

Documented performance of the new NASA Seasonal-to-Interannual Prediction Project-2 climate model using radar and passive microwave data. These results are being used to optimize the model physics formulations.

Support development of the Mesoamerican Biological Corridor by completing the transfer of remote sensing analysis technology to the Central American partners.

Conducted two training workshops for Central American scientists on remote sensing for land cover and land use change analyses. Participated significantly in the development of the first regional Central American Ecosystems Map. Developed the first set of regionally coordinated geographic information system based layers jointly with the national geographic institutes of the seven Central American countries and Mexico.

Demonstrate the importance of physical measurements to characterize urban surface properties for parameterization in climate and air quality models.

Model runs have been made using NASA-derived remote sensing data for a number of air quality episodes in Atlanta to initially assess the impact of urban land surface characteristics on enhancing the production of ground-level ozone as a result of the Urban Heat Island effect.

Develop and promote the use of remote sensing, geospatial technologies, and analysis products by decision makers and transportation specialists as part of the Department of Energy/NASA National Consortia on Remote Sensing in Transportation.

A needs assessment was completed and published, and some benchmark activities have been completed and others initiated that demonstrate the utility of remote sensing in streamlining environmental assessment in transportation development.

Operate and maintain a Geostationary Operational Environmental Satellite (GOES) ground station to foster the use of geostationary satellite data in regional applications and to support improvements in short-term regional weather prediction.

GOES ground station successfully operated. Derived products produced from the data are available in the NWS Huntsville Forecast Office decision support system and are used in forecast preparation.

Metrics

FY 2002 Global Hydrology and Climate Center Metrics—continued

Support NSSTC outreach efforts by providing research advisers and speakers on Earth science research to teachers and students.

Earth Science researchers participated in graduate-level classroom instruction and research advising; outreach to local K–12 schools; presentations at many seminars and conferences with wide attendance by undergraduate and graduate students.

Develop detailed plan for lightning observations on a geostationary platform via the Earth system science pathfinder opportunity.

A very detailed comprehensive proposal was submitted to NASA. Alternate approaches for placing a lightning-mapping sensor in geostationary orbit were presented and discussed. There have also been extensive discussions with NOAA on placing the sensor on either GOES P or R. Sensor design has matured over the past year.

Demonstrate ability of UAV for remotely monitoring storms and measurement of key parameters.

ACES successfully employed an uninhabited aerial vehicle to (1) investigate storm electrical activity and its relationship to storm morphology; (2) provide validation for space-based lightning detectors; (3) study storm electrical budgets; and (4) validate the UAV technology for Earth Science remote sensing.

Successfully implement the Advanced Microwave Sensing Radiometer for EOS (AMSR-E) Science Investigator-led Processing System (SIPS) upon launch of the Aqua satellite.

All AMSR-E science algorithms were successfully integrated into the science computing facility, and were provided to the SIPS. The SIPS successfully processed the first data and generated science products—e.g., rain, water vapor, sea ice, snow, sea surface temperatures, etc.—on June 1, 2002. Since then, the SIPS has processed all data received in near real time and has begun reprocessing in preparation for public data release in May 2003.

Continue successful operations of the GHRC and continue its major role as a contributor to the running and organization of the Federation of Earth Science Information Partners (ESIPs).

Members of the GHRC continue to take leading roles in the ESIP Federation through their involvement in the Constitution and Bylaws Committee, Information Technology and Interoperability Committee, Finance and Appropriations Committee, and the SEEDS Working Groups and Study Teams.

Submit plan to establish a Regional Forecast Improvement Laboratory to accelerate the use of EOS data to address the NASA's short-term weather prediction initiative.

Plan was submitted and funding received from NASA Headquarters. Project is named SPoRT (Short-term Prediction Research and Transition Center) and is now linked from the U.S. Weather Research Program page of sponsored projects at http://www.uswrp.org.

Space Science Research

MSFC manages the Chandra X-Ray Observatory, Solar-B, Solar X-ray Imager (SXI), Gravity Probe-B (GP–B), and the Gamma Ray Large Area Space Telescope (GLAST) Burst Monitor (GBM) for Code S. In addition, MSFC is responsible for the overall design, development, integration, testing, and flight operations of the GP–B flight experiment. The GP–B objective is to test two extraordinary predictions of Einstein's Theory of General Relativity, namely geodetic precession and frame dragging, both of which describe distortions in the space-time continuum. In order to test these subtle effects, GP–B will fly ultraprecise gyroscopes aboard a drag-free spacecraft containing the world's largest space-qualified dewar.

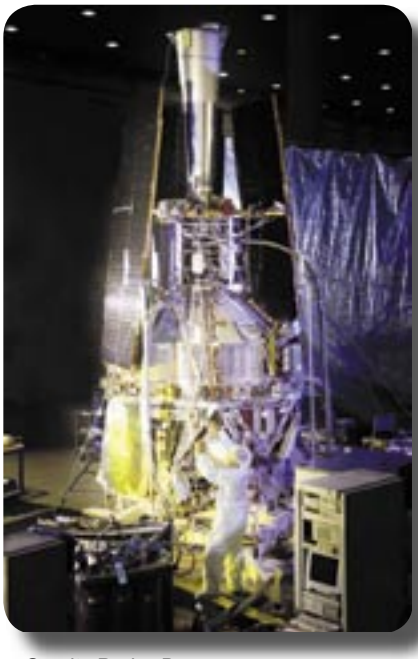
The MSFC Space Science group conducts fundamental research in six disciplines—cosmic-ray physics, gamma-ray astronomy, x-ray astronomy, solar physics, space plasma physics, and astrobiology.

Solar-B

MSFC also manages the U.S. contribution to the Japanese Solar-B mission. The goal of this international mission is to increase our understanding of the Sun and its impact on Earth. Scheduled for launch in 2005, this mission includes a significant contribution from the U.S. investigators and industry. Protomodel testing was completed in 2002 and flight instrument fabrication is on track for delivery in 2003 and 2004.

Solar X-ray Imager

Another MSFC payload is the SXI, which flies on the NOAA GOES–M satellite. The instrument serves as a solar activity monitor by imaging the x-ray emission from the Sun.



Gravity Probe-B.

Gravity Probe-B

MSFC manages the GP–B science payload and will manage the upcoming science mission. This mission will measure key features of Einstein's General Theory of Relativity by making precise measurements of the space-time continuum in near-Earth orbit. The significant highlights for the program in FY 2002 included successful completion of development of the final two payload electronics systems, payload acoustic testing, integration of the science payload into the spacecraft, integrated payload testing, and GP–B space vehicle acoustic testing.

Gamma-Ray Large Area Space Telescope Burst Monitor

The project is an international partnership project being conducted with the Max Planck Institute (MPE)/ Germany. The primary objective for GBM is to enhance the science return of the GLAST Large Area Telescope in the study of gamma ray bursts (GRBs). The GBM will detect GRBs over a large solid angle and will measure the spectra of the bursts over a wide energy band and with high temporal resolution. GBM will also determine the direction of the bursts in real time such that repointing of the main instrument can occur.

Metrics

FY2002 Gravity Probe-B Metrics

Launch GP–B in October 2002.

Development of the final payload electronic systems took more time than anticipated, and the planned October 2002 launch date had to be postponed to 2003.

Mission Lifetime of 16 months.

All testing to date confirms this expectation.

Measurement accuracy for relativistic drift of 0.5 milliarcsecond/year.

All testing to date confirms this expectation.

FY 2002 Solar-B Metrics

Achieve launch readiness by August 2004.

Launch was moved to September 2005 per the request of the ISAS/Japan. This metric is on track.

Mission lifetime of three years.

This metric is on track.

Deliver engineering models to ISAS by March 2002.

Completed.

Delivery of focal plane instrument to ISAS by November 2002.

Delivery of the focal plane instrument to ISAS was moved to October 2003 to reflect ISAS launch date slip to September 2005. This metric is on track.

0.5-m optical telescope resolution of 0.25 arcseconds.

Focal plane instruments on track to preserve the highest resolution of which the telescope is capable (<0.25 arcseconds).

Deliver x-ray telescope to ISAS by January 2004.

This delivery date has been changed from July 2003 to January 2004.

FY 2002 Solar X-ray Imager Metrics

Launch SXI on GOES-M.

SXI was launched on GOES-M on July 23, 2001. SXI and the spacecraft completed postlaunch testing and were placed in a storage mode on December 20, 2001, as a backup to the currently operational GOES spacecraft.

Mission lifetime of three years.

Metric on track and valid.

Full-disk soft x-ray imaging of the Sun, including solar flares and coronal holes.

Instrument performance was verified during on-orbit tests.

FY 2002 Gamma-Ray Large Area Space Telescope Burst Monitor Metrics

Launch GBM September 2005.

Launch was moved to September 2006 due to GLAST mission slip.

Mission lifetime five years.

This metric is on track.

Detectors delivered by MPE by September 2003.

Detector delivery moved to July 2004 to accommodate GLAST mission slip.

Observe GRBs from 5 keV to 30 meV.

Metric was changed to measure GRBs from 10 keV to 25 meV to reflect the GBM requirement.

Scientific Research

Cosmic-ray Astrophysics

The Advanced Thin Ionization Calorimeter (ATIC) was launched on its second balloon flight from Antarctica in late December to measure the energy spectrum of individual cosmic ray elements. Its purpose is to study the validity of the supernova shock wave acceleration model that makes specific predictions about the cosmic ray energy spectrum as a function of elemental charge. A balloon at 120,000 feet is above 99 percent of the Earth's atmosphere, allowing incoming cosmic rays to escape local collisions prior to striking the ATIC detectors.

Gamma-ray Astronomy

Soft Gamma Repeaters (SGRs) and Anomalous X-ray Pulsars (AXPs) were identified as a peculiar evolutionary branch of neutron stars, distinct from the much more common class of radio pulsars. SGRs and AXPs are currently believed to be neutron stars with enormous magnetic fields—hence dubbed "magnetars." This type of neutron star was first conjectured in 1992 by two theoretical astrophysicists, but their discovery and identification was only achieved in 1998, through observations carried out by a team of researchers. The work of two teams resulted in the Rossi Prize for 2003 being awarded to Rob Duncan (University of Texas-Austin) and Chris Thompson (University of Toronto) and to Chryssa Kouveliotou (NSSTC/USRA), for the theoretical prediction and observational verification of magnetars—neutron stars with extraordinarily strong magnetic field. An article on this topic is the Scientific American cover story in the February 2003 issue. Additionally, recent observations of x-ray pulses from AXPs by a team including NSSTC researchers confirmed these objects are magnetars. This result was featured in Nature, September 12, 2002.

X-ray Astronomy

The Chandra X-ray Observatory made observations of Jupiter and the Galilean moons. X-ray emission associated with Jupiter's polar aurorae had been studied previously with the Einstein and Roentgen Satellite (ROSAT) xray observatories, but Chandra's superb spatial resolution led to some surprising findings. The polar xrays come from inside the main auroral oval rather than outside as expected, implying that the exciting particles originate much farther out in the Jovian magnetosphere than previously thought, perhaps even entering directly from the solar wind. The x-rays were found to fluctuate with an approximately 45-min quasi-periodicity, a finding not yet understood. Finally, very faint x-ray emission was discovered emanating from the Io plasma tours and from the innermost Galilean moons, Io and Europa.

Space Plasma Physics

The evaluation of the Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics (TIMED) mission data at MSFC focuses on the effects of energetic particle fluxes on the energy balance of the lower thermosphere and mesosphere through particle heating, Joule dissipation, and chemically active minor species. These energy inputs alter the global scale characteristics of the neutral atmosphere forcing large-scale, long-lasting changes in the ionospheric plasma and, through the plasma medium, changes in global-scale patterns of conductivity, joule and particle heating, current systems, and electric fields. Researchers at NSSTC concentrate on the impact of the changing neutral atmosphere on the electrodynamic coupling and on the details of the energy deposition. We have modified the computer model for the Earth's ionosphere/plasmasphere to better incorporate the phenomena addressed above and are currently evaluating the model results against the mission data.

Solar Physics

The Solar Ultraviolet Magnetograph Investigation (SUMI) will measure the solar magnetic field in the transition region and upper chromosphere from a rocket-borne platform. At these heights in the solar atmosphere, the field is no longer constrained by the surrounding plasma, and consequently, it has been proposed that magnetic instabilities in this region drive flares and coronal mass ejections. SUMI is a technology demonstrator mission for the Magnetic Transition Region Probe that is included in the 2002 Sun-Earth Connection Roadmap. SUMI was selected for full funding by the Office of Space Science for 3 years, leading to an expected sounding rocket flight of the instrument in late 2005 or early 2006.

Astrobiology

Research at the NSSTC Astrobiology Laboratory includes the study of novel microbial extremophiles. Extremophiles are microorganisms that live in the most extreme environments on Earth. They are important to astrobiology as they help to establish the limitations and distribution of life on Earth and provide clues as to where and how we should seek evidence for life elsewhere in the cosmos. Alkaliphiles and acidphiles live at the extreme ranges of pH. Some flourish in hypersaline alkaline evaporite minerals of closed volcanic basins such as Mono Lake in Northern California. Mono Lake represents a good model for conditions that might have existed in closed volcanic basins or impact craters of Mars, such as the possible Mars Landing Site—Gusev Crater.

Engineering Directorate

The Engineering Directorate (ED) provides state-of-the-art engineering services for MSFC's product line directorates, supports scientific investigations that broaden knowledge of Earth and the universe, and performs advanced technology development across a broad array of technical disciplines. During FY 2002, ED personnel made significant accomplishments while providing engineering services in support of the Space Shuttle, Space Transportation, Flight Projects, and Science customers, as well as technology development through both independent and team efforts. The Marshall Values are incorporated into every aspect of the services provided by ED.

Engineering Support for Space Shuttle Projects Office

During FY 2002, ED made significant contributions to the Space Shuttle Program, providing engineering support and performing critical failure analyses that kept the Shuttle flying. ED supported the investigation of defective connectors identified during SRB preinstallation testing. This investigation identified, isolated, and corrected manufacturing process escapes and added process controls to prevent recurrences.

Support was provided to the Shuttle Mobile Launch Platform Hold-Down Post anomaly investigation team in troubleshooting the loss of redundancy of the SRB/Mobile Launch Platform hold down bolts during the launch of STS–112. The team isolated the failure to a single electrical path and recommended corrective action to be taken to prevent a recurrence on any future Shuttle launch.

ED performed extensive analysis and tests that led to understanding of the cause of Shuttle Orbiter flowliner cracks discovered prior to STS–112. The ED team developed models and performed structural dynamic, fatigue/fracture, modal testing, and analyses. ED developed and qualified the welding technique used to repair the flowliner cracks, mitigating this critical safety issue and allowing the Shuttle's return to flight. ED also led the composite process repair team for evaluation and repair of the Shuttle Remote Manipulator System (SRMS) that was damaged prior to the STS–113 launch.

An SSME Health Management Computer–Integrated Rack Assembly (HMC–IRA) was designed to provide a method of verifying the concepts required to modify an SSME's performance during flight in off-nominal conditions. In further support of the SSME, ED completed the Block II modal tests, developed a ground rules document for Block II revisions to SSME vibration environments, and provided modeling and analysis support for several investigations involving the low-pressure and high-pressure turbopump components. ED also provided tooling for the SSME and RSRM using rapid prototyping technologies and supported the RSRM project office in the resolution of crack-like indications found in the motor clevis/tang joints. Kevlar feedline overwrap positioners, conformal sanding blocks, and fiber optic nozzle lay-up tools were three-dimensionally printed within a few days to provide immediate assistance, as well as significant cost savings, to the Shuttle program.

ED demonstrated circumferential Self-Reacting FSW by joining two 14-ft. diameter test rings as a pathfinder for implementation on the Shuttle's ET. Hot gas testing was also conducted on the ET's foam insulation and SRB's insulative and ablative materials.

Engineering Support for Space Launch Initiative Program

ED was instrumental in establishing the tools and processes used by the Vehicle Integrated Performance Analysis team for independent assessment of vehicle system design, and also provided insight for SLI architecture studies. ED provided significant insight for a number of advanced technology development projects including the X–37 and DART flight demo projects.

An Advanced Video Guidance Sensor (AVGS) for automated rendezvous and capture was developed to support the DART flight demo. Prototype AVGS units were delivered and tested. Orbital Sciences Corporation is developing the AVGS, using technology developed by ED. This sensor will guide the DART vehicle in the final stages of its rendezvous mission with the Multiple Path Beyond Line of Sight Communications (MUBLCOM) satellite. This unmanned automated rendezvous flight control technology lays the groundwork for an identical capability for the OSP.

ED produced full-size mockups of the Boeing Rocketdyne MK–67 turbopump using rapid prototyping techniques. These mockups provided for early fit checks for the pump support skid's integration with facility feed and discharge lines, thus reducing exposure risks to the actual test article. The TRW Thruster Body

Mockup, fabricated by the Rapid Prototyping Lab, was mounted in the test fixture and used to build up the liquid oxygen and liquid hydrogen feedlines and run instrumentation cables and sensor lines to the test article. Other models prototyped for SLI included inducers, advanced valve assemblies, and flow ramps for a Pratt & Whitney partial emission turbine rig design.

ED enhanced existing test capability by bringing a Cryo-Biaxial Permeability Apparatus (CBPA) online in 2002. The CBPA subjects large material specimens to a biaxial strain state while exposed to liquid hydrogen at representative tank pressures. The CBPA was utilized to conduct testing on promising materials for use in cryogenic liquid hydrogen tanks. ED also provided preliminary evaluation and validation of cryotank tooling options and the involved processes for the metallic and composite cryotank manufacture. Four aluminum alloys were evaluated for potential application to a reusable metallic cryotank. The candidate metals were tested for fracture toughness and fatigue after thermal exposure, simulating the expected service of a reusable tank. ED also provided independent tank wall sizing analyses for the SLI cryotank program.

ED performed structural dynamics support to COBRA and RS–83 engine systems by evaluating loads methodology and analysis.

Engineering Support for Space Transportation Directorate

ED supported development of the ProSEDS, performing strength analyses and delivering the instrumentation, control, and signal conditioning electronics for the Differential Ion Flux Probe. This instrument will be used to measure the plasma environment in which the ProSEDS demonstration is conducted. Working jointly with the Space Transportation Directorate, ED developed a spiral wrapping process and mechanical system for applying electrically conductive cross-straps to the ProSEDS flight tethers. The cross-straps are used to mitigate the risk associated with a partially severed tether. ED also developed a technique to form and secure a termination loop at the end of the tether to interface with the ProSEDS endmass. ED also successfully performed functional testing and thermal design, and system-level thermal vacuum testing.

ED developed an innovative technique for determining statistically accurate radial thermal expansion of carbon fibers. This new capability enables modeling of composites on a constituent level, promotes proper material selection, and provides

explanation of certain aspects of composite behavior. ED also supported the supercritical cryogenic injector spray characterization, high-performance antiproton trap, and the Plasma Propulsion Thruster designs for MSFC's new PRC.

Engineering Support for Flight Projects Directorate

ED provided engineering support to the *ISS* Program Node 2 and Node 3 projects. Node 2 is a building block to connect other *ISS* elements and will provide for temporary habitation and accommodates the distribution of commands and data, audio, video, electrical power, atmosphere, water, and thermal energy to adjacent elements. Node 3 is a station building block whose primary function is to provide the *ISS* crew with air revitalization and water processing functions, as well as to connect and service other *ISS* elements via berthing ports. ED has supported the Node 2 and Node 3 avionics elements—electrical power systems, software, and command and data handling. In addition, ED has completed development of Node 2 hardware/software integration procedures and dry run their execution.

Six special racks in Node 3 will house the *ISS* regenerative ECLSS. ED is developing the urine processor firmware controller, sensors, and performing the cable harness design and fabrication for the Urine Processor Assembly of the ECLSS racks. ED completed the strength analyses of the ECLSS racks. ED also completed microgravity testing and isolator performance assessment for the Development Distillation Assembly, and completed analyses and derivations of ECLSS component random vibration loads and environments. ECLSS will provide potable water through the reclamation of wastewater, control oxygen partial pressure, and introduce oxygen into the atmosphere to support human and animal metabolic needs.

Engineering Support for Science Directorate

The g-LIMIT hardware and software were developed and produced in-house by ED. g-LIMIT is an active vibration-isolation system, which can be utilized by payloads in the *ISS* MSG. Among this year's accomplishments, ED completed measurement and verification tests on g-LIMIT's position sensor. The two main electromechanical assemblies include 11 in-house designed and manufactured electronic boards, seven commercial off-the-shelf (COTS) power supplies, three COTS boards, and over 20,000 lines of code. g-LIMIT was delivered to the *ISS* program in late 2002, and is scheduled for launch aboard STS–114.

Other Science Directorate (SD) projects supported by ED in 2002 included the MSRR, the QMI, and Delta-L. ED developed the MSRR master controller unit, software, and cables, and completed strength analyses and the majority of the flight drawings. QMI is a high-temperature translating vacuum furnace with both gradient and cold quench capabilities. ED developed the QMI cabling and motor control board and completed design and chill block performance developmental testing. The first ground unit was fabricated and assembled as flight hardware in 2002. Delta-L, a microgravity materials experiment that utilizes video imaging for science data to document phase changes, progressed from an engineering model to flight configuration in 2002. Its assembly has been completed and is scheduled to ship in mid-2003. ED blended COTS hardware with a custom design to create a robust, functional unit. Delta-L's innovative design has been recognized by several publications and received the Imaging Solution of the Year award in the category of Microscopy from Advanced Imaging magazine.

ED conducted materials compatibility testing of solutions and containment materials for the PCAM, Diffusion Controlled Crystallization Apparatus for Microgravity, Enhanced Gaseous Nitrogen, and other assorted MSG experiments.

For the GP–B Project, ED assessed GP–B secondary structure for random vibration environment induced by transport in Super Guppy, created a dynamic model, performed structural dynamic analysis on GP–B Guppy Adapter, and developed input for a transient analysis of GP–B for the Super Guppy landing environment. ED also completed independent thermal/fluid modeling of GP–B's liquid helium dewar system to assess mission lifetime.

ED continued its efforts on the Next Generation Space Telescope (NGST) by developing and verifying the capability to thermally model/correlate free molecular helium regimes in the XRCF to support rapid cooling of NGST mirrors. ED also modeled and analyzed different NGST telescope concepts and provided structural/optical deflection analyses of the NGST mirrors that led to the down-select decision.

Technology Development

ED continued to be actively engaged in technology research and development in line with MSFC core strategies in FY 2002.

Research and development efforts included: advanced research in the area of Space-based Inflatable Structures; inflation techniques and analysis tools; development of new analytical techniques (Random Sine Loads Combination); developed a new, more efficient first-order reliability method based on Broyden's method for solving nonlinear equations; concluded a two-year effort to accurately characterize rocket engine nozzle sideloads and verified fluid/structure interaction as inherent part of rocket nozzle side loads phenomena; completed development of an accurate method for using plate finite elements instead of more computationally intensive solid elements for modeling fillets in structures; and completed dynamic analyses for Turbine Performance Optimization (TPO) test rig.

ED also supported activities coordinated by the Technology Transfer Department through management of multiple Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) activities, and by participating in the Technology Investment Program (TIPs). ED also participated in the CDDF program, performing 24 technology projects relevant to the product lines and to MSFC core values. ED employees were active in publishing and presenting scientific papers in trade journals and at technical conferences. Over 123 technical publications were written and released by ED personnel.

Additional Activities

Advanced Computing

In 2002, the Advanced Computing Technologies Team issued and disseminated its second report describing the Center's advanced computing efforts, soft computing, emerging, and future technologies such as biological and quantum computing. A collaborative project was developed between ED and Oak Ridge National Laboratory to use genetic optimization techniques for a multimegawatt nuclear space exploration vehicle. The application of advanced computing technologies to robotics continued. Further efforts include teaming with the Science Directorate's Space Optics Manufacturing Technology Center in the area of genetic algorithms to solve a phase retrieval problem for segmented optics; collaboration with the JPL Bio-inspired Technologies Group to evolve motor controllers on a Field Programmable Transistor Array; and supporting Austin Peay State University in the fabrication of a tensegrity structure to verify analytical predictions of vibrostructural properties.

NASA Technical Standards Program

During FY 2002, the NASA Technical Standards Program focused its efforts on the further development of the Standards Update Notification System and the Lessons Learned/Best Practices/Applications Notes—Standards Integration System. This included extensive interactions with MSFC Programs and Projects with expansion to various Programs and Projects at other NASA Centers. The Standards Update Notification System was embraced by the NASA Chief Engineer as the primary mechanism for use by the Agency to maintain updated information on Technical Standards products being used in design, development, operations, and updates to operating flight systems. The Lessons Learned/Best Practices/Applications Notes—Standards Integration System continues to receive attention from other Agencies and aerospace companies relative to its unique approach in identifying Lessons Learned/Best Practices that are applicable to specific engineering activities involving Technical Standards.

The Program's Agencywide Full-Text Technical Standards System also continues to receive increased usage throughout the Agency by both internal staff and Supporting Contractors. FY 2002 saw an increase of 230 percent in usage over FY 2001. This system is now the primary Agency access for technical standards products with essentially all Centers having phased out their individual sponsorship for access to technical standards issued by NASA, the Department of Defense, and nongovernment, national, and international technical standards developing bodies. In addition, this System provides the basic inputs for the Standards Update Notification System.

During FY 2002, the NASA Technical Standards Program increased its initiative to cultivate additional proposals for the development of NASA-unique technical standards where non-NASA standards are not available to meet the Agency's needs. At the end of FY 2002, 20 NASA-developed technical standards had been approved as NASA Preferred Technical Standards—15 under development and five being considered for sponsorship. To date, approximately 3,000 non-NASA (nongovernment and military) standards have been adopted as NASA Preferred Technical Standards.

Registered users for the NASA ACCESS and PUBLIC ACCESS domains increased significantly during 2002. More information on the Program can be found at the NASA Technical Standards Program Web site—http://standards.nasa.gov.

Metrics

FY 2002 Engineering Directorate Metrics

The Engineering Directorate embarked on implementing three initiatives to help achieve the Directorate's vision: "Engineering excellence enabling our customers' mission success." The initiatives focused on three aspects of ED performance—knowledge, processes, and tools.

Knowledge—Learning Organization: Build a learning organization to enable a highly qualified and motivated workforce with proper skills.

ED created an internal, interdisciplinary team committed to creating an environment that strengthens engineering excellence and nurtures innovation by expanding knowledge sharing, active learning, and the proactive application of lessons learned. The learning organization team's members completed their preliminary assessments of current training methods within their organizations, including identifying local examples of potential role models for learning leadership. Members are condensing the assessments into an easily referenced booklet to benchmark current practices, promote cross-fertilization, and help explore and integrate the best practices of world-class learning organizations. Team members completed evaluation of the lessons learned from Phase I of the Comprehensive Systems Skills Initiative (CSSI). As a result, Phase II of CSSI consists of new and revised modules, including new curriculum elements for integrating engineering solutions and capabilities. ED implemented new forums for in-house seminars addressing advanced technology issues and cross-disciplinary research and development projects. New in-depth discipline training is being addressed as the challenge of capturing and effectively sharing very specialized aerospace knowledge, expertise, and the significant lessons of experience are being constructively confronted.

Processes—Integrated Engineering Solutions (IES): Enhance the integration of engineering processes across the engineering disciplines.

A process team, established with membership from all Directorate Departments as well as representation from other MSFC organizations, uses a modular approach for identifying process improvements. The team completed review of several modules and recommended strategies for improvements. These reviewed modules include configuration management, documentation release, and procurement strategy. The team is currently addressing engineering parts list development and management. The team expects to complete review of all identified modules by the end of the 2003 calendar year in accordance with the IES schedule.

Tools—Integrated Engineering Capability (IEC): Integrate and fully utilize tools and equipment.

The IEC project took the first steps toward creating an advanced environment that will fully integrate engineering processes throughout the lifecycle of the product. The project selected a product lifecycle manager as the tool that will be used to integrate engineering tools and engineering data. The IEC will serve all MSFC Engineering and will improve efficiency, quality, interfaces with partners, and interfaces with other centers. IEC is a part of the Code M Collaboration initiative where MSFC, JSC, KSC, and Stennis Space Center share development responsibilities and, after implementation, share engineering data and tasks among Centers.

Document management is MSFC's initial process for implementation. The IEC project has worked closely with the Configuration and Data Management group to develop use cases for the document management process. Users will review the use cases for further definition and refinement. Once approved, IEC will use cases to develop workflows and, ultimately, an automated process for document release.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Principal Center Support Activities

NASA Automated Data Processing Consolidation Center

During FY 2002, the NASA Automatic Data Processing Consolidation Center (NACC) convened a System Consolidation Logical Partition (LPAR) Working Group that identified and resolved more than 50 issues and consolidated six test LPARs into one, reducing the number of NACC LPARs by 20 percent. Also, improved methodology enabled the upgrade of 15 out of 16 system images to the z/Operating System in a 4-month period, making it the most efficient system rollout performed to date. NACC also supported a 4-week FY 2002 Federal Information Systems Control Audit Manual audit that included network penetration testing. A Web page for an interim system for ordering/tracking Oracle software licenses through the Agencywide Enterprise Licensing Agreement with Oracle was created and implemented. NACC saw dramatic changes to both the number and types of systems in its Data Center. New Agencywide projects include the Integrated Financial Management (IFM), SLI, and NASA Computing and Communication Services. Also, the design, procurement, installation, and customization of the NACC Storage Area Network was completed. For the sixth consecutive year, NACC service level goals were raised in one or more service areas from 99.8 percent to 99.9 percent.

In addition to operating and maintaining mainframe class computers and servers that support Agencywide administrative and programmatic processing requirements, the NACC supported the yearly financial audit of six NASA systems performed by PricewaterhouseCoopers. The NACC also supported the MSFC Office of Inspector General audit of the Space Shuttle Systems.

Sustaining Engineering Support for Agencywide Administrative Systems

Sustaining Engineering Support for Agencywide Administrative Systems continued to provide sustaining engineering support to the Agencywide administrative systems. Regulatory/statutory and policy changes were implemented expeditiously into the various applications, including the NASA Personnel/Payroll System, Consolidated Agency Personnel/Payroll System, Acquisition Management System, NASA Equipment Management System, NASA Property Disposal Management System, NASA Supply Management System, and the NASA AdminSTAR training system.

NASA Integrated Services Network

In FY 2002, NASA Integrated Services Network (NISN) provided wide-area network video, voice, and data services to Agency customers at or above the established standards of excellence, in addition to managing services such as video teleconferencing (ViTS); administrative and mission voice, facsimile, inter-Center mission and administrative data; and Internet access. Significant effort was expended to meet new and changing requirements for growing programs, such as the EOS, *ISS*, the Deep Space Network, and the IFM Program.

In FY 2002, NISN provided 5,353 Agencywide ViTS sessions and 72,835 voice teleconferencing sessions, meeting operational performance objectives despite growing usage in these services. In FY 2002, NISN received 1,038 new requests for service and completed 789. NISN mission systems and operations staff

NISN at MSFC provides Shuttle data information for the operation of MSFC's Huntsville Operation Support Center during Shuttle missions.

supported Shuttle launches STS–108, STS–109, STS–110, and STS–111; one SEALAUNCH mission, SOYUZ/ISS–3S and –4S; four ATLAS missions; three TITAN missions; three DELTA missions; one Pegasus mission; two Ariane missions; and one ROCKOT mission.

In FY 2002, NISN implemented the Mission Outage Notification system, completed the mission voice compression project, developed a secure collaborative ViTS capability, created and distributed service brochures, upgraded the mission support backbone, provided support to NASA Centers and facilities to prepare and recover from hurricanes and typhoons, and supported Consolidated Space Operations Contract (CSOC)'s storefront activity, which is a mentoring program for students at Alabama A&M University and Oakwood College.

Accomplishments of the Russian services team include updating low-bandwidth videoconferencing systems, upgrading routers and network software, reprovisioning circuits due to vendor bankruptcy, installing a continuous video feed of NASA TV Progress coverage into Russian locations, and connecting Russian phone switches into the JSC telephone system.

An annual customer forum was held to brief customers on service offerings and initiatives and to solicit customer input to improve NISN services and supporting processes. Additionally, site visits were initiated to meet individually with customers at each major NASA facility/Center.

Digital Television

The Space Act Agreement with Dreamtime Holdings was terminated by NASA in May 2002. Agency goals for the efficient transition from analog television to digital must now be accomplished by NASA. All Centers' plans for standard definition TV transition were updated and status provided to NASA management. Detailed planning and budget estimates were provided for transitioning NASA TV from one single analog channel to multiple digital channels. Post-flight analysis was conducted on the high-definition TV (HDTV) camera that flew throughout Increment-3 on *ISS*. Planning and hardware certification began in preparation for a system capable of live HDTV downlinks from the *ISS*.

Financial Management and Accountability

Accounting Operations

During FY 2002, MSFC's Accounting Operations Office prepared for the conversion to the new IFM system and supported the annual financial audit in addition to carrying out normal operations. During this process, the Accounting Operations Office was able to close out numerous old contracts, thus limiting the amount of information that had to be converted to the new IFM system. Concurrently, the Accounting Operations Office worked with the NASA Headquarters and other Centers' financial management offices in providing information for the annual financial audit. This was a significant task in itself, and was made more difficult by the nature and priority of other activities. The Accounting Operations staff successfully met all information requests, thus contributing to NASA receiving an unqualified audit opinion on its financial statements.

Support for Agency Contract Administration and Audit Services

MSFC has responsibility for NASA's financial management support for Agency Contract Administration and Audit Services (CAAS). This includes responsibility for managing the cost and billing information and Agency-level accounting for CAAS services provided to NASA by external audit organizations such as the Defense Contract Audit Agency and the Defense Contract Management Agency.

MSFC also has responsibility for NASA financial management support for Agency Reimbursable Collections of Contract Administration and Overhead from NASA reimbursable customers that provided reimbursement to MSFC salaries and NASA Federal Telephone Services costs.

Earned-value Management

During FY 2002 as the Agency Principal Center for Earned-value Management (EVM), MSFC continued the effort to establish an effective, value-added NASA EVM Program providing oversight and guidance for the implementation of EVM policy throughout the Agency. MSFC has provided assistance to numerous projects to properly implement EVM principles and practices including EVM training; defining EVM requirements; Integrated Baseline Review training, preparation, and support; and project analytical support. MSFC is also developing a simplified EVM approach for in-house EVM efforts.

Integrated Financial Management Program

The goal of NASA's IFM Program is to improve financial management throughout the Agency. The mission of the restructured IFM Program is to improve the financial, physical, and human resources management processes throughout the Agency. IFM will reengineer NASA's business infrastructure in the context of industry best practices and implement enabling technology to provide necessary management information to support the Agency's strategic plan

implementation. Successful implementation of the program will allow NASA to:

- Provide timely, consistent, and reliable information for management decisions.
- Improve accountability and enable full-cost management.
- Achieve efficiencies and operate effectively.
- Exchange information with customers and stakeholders.
- Attract and retain a world-class workforce.

MSFC plays several major roles in the IFM Program.

Core Financial Project

The Center manages the Core Financial Project, which is the first of several potential IFM projects. The IFM Core Financial Management Project provides the management and technical leadership for the Agencywide implementation of standard systems and processes necessary to support the Agency's financial management activities. The Core Financial Project will provide the backbone of the IFM Program and consists of the following components: Standard general ledger, accounts receivable, accounts payable, budget execution, purchasing, and cost management. In addition to managing the project, MSFC will serve as the pilot Center for implementation of the core financial software.

Administrative Systems Implementation Project

MSFC has also been asked to manage the implementation of the remaining IFM Program projects that will utilize the SAP software suite. The IFM Program Administrative Systems Implementation Project will provide the management and technical leadership for the Agencywide implementation of standard systems and processes necessary to support the Agency's administrative activities. The scope of this project will include Human Resources, Payroll, and Integrated Asset Management. The scope of the project will be finalized in FY 2003.

Integration Project

MSFC also manages the long-term IFM Integration Project. This project manages all functional, application, and technical integration within the scope of the IFM Program. The IFM Integration Project is responsible for ensuring that the individual IFM software modules work together and collectively satisfy the defined Agency IFM business drivers. The Integration Project will also be responsible for maintaining the Agency business and software applications architecture, and designing and implementing the information technology architecture that supports the deployment and operation of the IFM modules.

Logistics Business Systems Operations and Maintenance

Leadership was provided in implementing and sustaining Agency logistics business systems that provide the necessary automated tools to professionals supporting the NASA workforce. These logistics business systems provided responsive and cost-effective logistics business systems to all NASA strategic enterprises and logistic business process customers.

NASA Materials Replacement Technology Team

The NASA Materials Replacement Technology Team (NMRT2), formerly known as the NASA Operational Environment Team, accomplished several objectives during CY 2002. The NMRT2 provides a continuing capability to support and facilitate materials replacement technology activities related to achieving environmental compliance in the design, development, test, use, and production of aerospace hardware.

The NMRT2 cosponsored the 5th Conference on Aerospace Materials, Processes, and Environmental Technologies (AMPET) at the Von Braun Center during September 16–18, 2002. The AMPET provided a forum in which the materials, processes, manufacturing, and environmental communities showcased innovative technologies vital to the evolution of safer, operational, next-generation, reusable, and expendable aeronautics and space vehicle systems. During the conference, aerospace practitioners described, reviewed, and critically assessed advances in technologies for upgrading existing systems and developing future airframe propulsion, transportation, and structural hardware systems. The conference attendance exceeded 350 participants including 31 exhibitors. Overall, 75 technical papers and 12 technical posters were presented during the AMPET conference.

The NMRT2 continued its partnerships with the SEA team and the Joint Group on Pollution Prevention (JGPP). The SEA initiative focuses on ensuring continued environmental compliance of Space Shuttle program elements through awareness, communication, and resolution of environmental, materials obsolescence, and materials replacement technology issues. JGPP is a partnership between the DOD, NASA, and industry with goals of reducing duplication of effort when testing alternatives to hazardous materials.

The Principal Center for Review of Clean Air Act Regulations

A Memorandum of Agreement between NASA HQ Office of Systems Management (Code J) and Office of Space Flight (Code M) and MSFC Materials, Processes, and Manufacturing Department establishes the roles and responsibilities of the parties and sets forth

the principles governing the Principal Center agreement for support of NASA's review of Clean Air Act regulations.

The Principal Center for Review of Clean Air Act Regulations provides proactive management in assessing environmental regulations affecting the design, development, test, production, and operation of NASA programs and supporting facilities. During CY 2002, the Principal Center assessed 13 Clean Air Act regulations for impacts to NASA's programs and facilities. National emission standards for the following six source categories were found to have potential impacts: Miscellaneous Coating Manufacturing, Semiconductor Manufacturing, Engine Test Cell/Stands, Site Remediation, Fabric Coating, and Surface Coating of Miscellaneous Metal Parts and Products.

National Center for Advanced Manufacturing

NASA has designated the Principal Center Assignment to MSFC for implementation of the National Center for Advanced Manufacturing (NCAM). NCAM is NASA's leading resource for the aerospace manufacturing research, development, and innovation needs that are critical to the goals of the Agency. Through this initiative, NCAM's people work together with government, industry, and academia to ensure the technology base and national infrastructure are available to develop innovative manufacturing technologies with broad application to NASA Enterprise programs and U.S. industry. Educational enhancements are ever-present within the NCAM focus to promote research, to inspire participation and to support education and training in manufacturing.

Many important accomplishments took place during 2002. Through NCAM, NASA was among five federal agencies involved in manufacturing research and development (R&D) to launch a major effort to exchange information and cooperate directly to enhance the payoffs from federal investments. The Government Agencies Technology Exchange in Manufacturing is the only active effort to specifically and comprehensively address manufacturing R&D across the federal government. Participating agencies include the Departments of Commerce (represented by the National Institute of Standards and Technology), Defense, and Energy, as well as the National Science Foundation and NASA. Also this year, a commitment was made to serve on the SpaceTEC National Aerospace Technology Advisory Board. SpaceTEC is a consortium of nine community colleges across the nation that are involved in Aerospace Technology training. MSFC's ongoing partnership with the State of Louisiana, the University of New Orleans, and Lockheed Martin Corporation at the Michoud Assembly Facility progressed significantly. Major capital investments were initiated for world-class equipment additions including a universal friction stir welding system, composite fiber placement machine, five-axis machining center, and ten-axis laser ultrasonic nondestructive test system. The NCAM consortium of five universities led by University of New Orleans with Mississippi State University, Tennessee Technological University, Texas A&M University, and Virginia Polytechnic Institute and State University provided wide-ranging engineering research, new degree/curriculum programs, and a Web-based lecture series. NCAM has fostered an important presence and leadership role within the national manufacturing community. Its progressive influence can be seen in government, industry and academia, and in national associations, professional organizations, conferences, workshops, and forums.

Other Support Activities

Spacelink

NASA Spacelink, one of NASA's primary education Web sites, is managed by the MSFC Education Programs Department for NASA Headquarters, with the support of the Center Operations Directorate's Information Systems Department. The NASA Spacelink team produced three Educator Focus articles that provided information to educators on where they can find NASA-produced educational and informational materials on specific themes. Spacelink also provided interim Agencywide Web site search services during the fiscal year, which allowed NASA Headquarters time to review new search engine software solutions.

MSFC also manages the NASA Education Home Page that serves as the Agency's gateway Web site for information about NASA education programs and services and the NASA Central Operations of Resources for Educators (CORE) Web site, which provides multimedia materials for teachers. MSFC's educational Web site teams contributed a NASA linkage campaign as a part of the Global Science and Technology Week (GSTW), an initiative of the White House Office of Science and Technology Policy. Team members created the GSTW Web site and assisted in the promotion of the event. Each of these Web sites (NASA Education Home Page, Spacelink, and NASA CORE), along with NASAexplores (which provides on-line lesson guides for teachers) is participating with an on-line customer satisfaction survey. Conducted by ForeSee Results, the survey is tied to the American Customer Satisfaction Index and allows precise measurement of customer satisfaction of Web site users, identifies areas of improvement, and can follow the impact of those improvements on the customer.

Human Resource and Payroll Information Systems

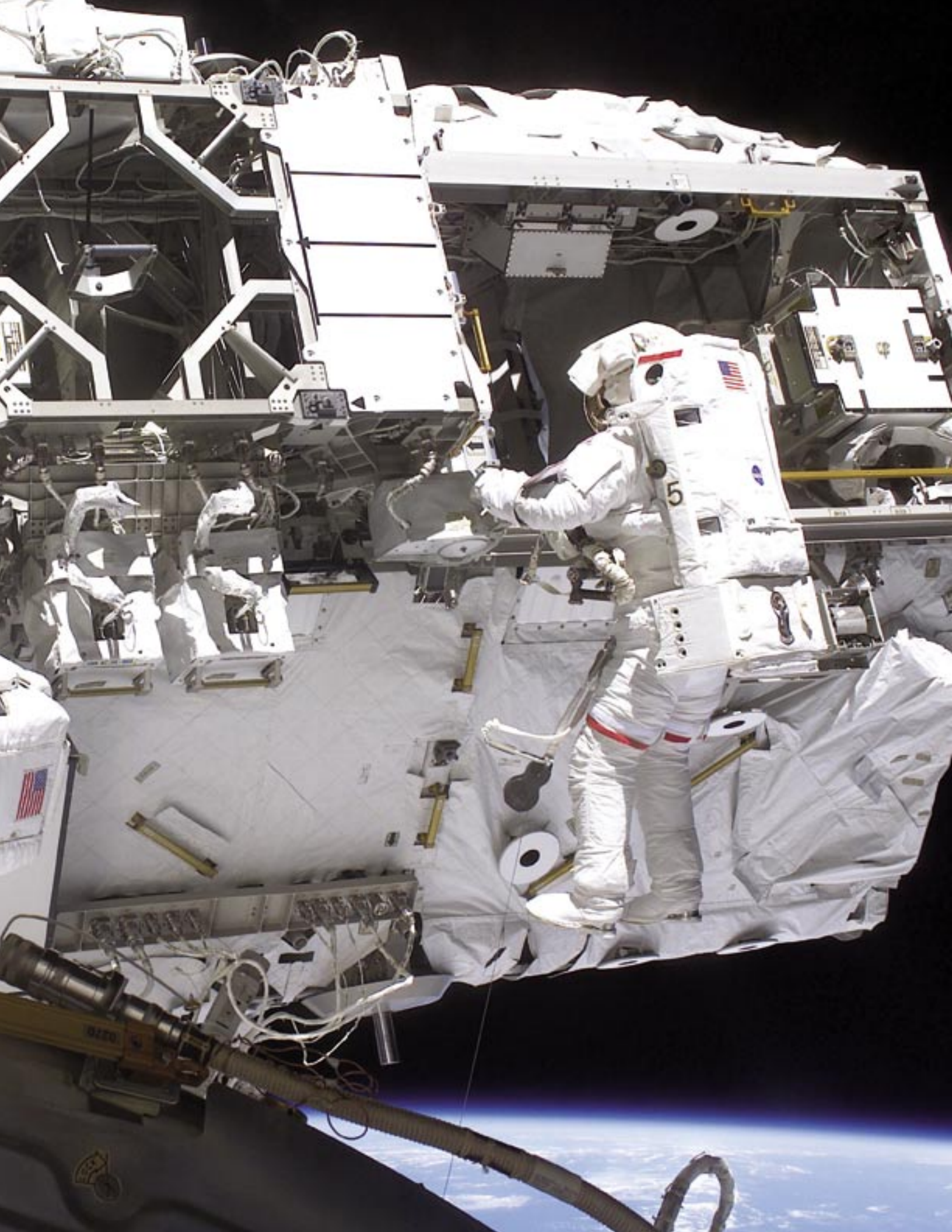
The White House has mandated that all federal agency payroll service delivery be consolidated and policies be standardized. The target date for the consolidation for all agencies is September 2004 and the effort is expected to save over $1 billion over a 10-year period. As a result, the Department of Interior (DOI) around the August/September 2004 time frame will perform NASA's payroll services. Several meetings have occurred with NASA and DOI, and an implementation plan will soon be developed. Currently, NASA is identifying systems that may be impacted by the payroll transition.

Agency Environmental Functional Review Support

The MSFC Environmental Engineering Department supported NASA Headquarters Code JE in their annual Environmental Functional Review at Jet Propulsion Laboratory. Code JE conducts environmental audits at each Center on a three-year cycle utilizing other Center Environmental personnel. This cross-utilization of personnel enhances technical knowledge while facilitating the One NASA concept.

NASA Secure Network

Center Operations provided leadership and technical expertise by developing and implementing a dedicated NASA Secure Network (NSN). The NSN is a Web-based classified network encryption system with MSFC serving as the system host for the Agency. Beyond providing NASA with secure e-mail, file sharing, and classified processing of data/voice/video, the NSN is designed to provide secure Internet access to 2,300 intelligence community and DOD Web sites



Institutional Products and Services

Marshall Space Flight Center Technology Transfer

The MSFC's Technology Transfer Department utilizes focused program areas designed to innovate, incubate, and accelerate technological advances—from conception, through development, demonstration, and commercial realization. It is a strategically focused program aimed at complementing the missions and objectives of the Agency while ensuring that NASA's scientific and technological advances help to sustain the competitiveness of U.S. industry. This multifaceted program fully aligns with the NASA Strategic Plan by leveraging technologies and resources from academia and industry, by fostering market-driven technology suppliers for NASA's future missions, and by utilizing a life-cycle approach to technology development and commercialization. The program supports National priorities by partnering with other agencies while remaining focused on NASA's major initiatives. In addition, the program contributes to the Nation's technology innovation and readiness by promoting awareness of NASA's market-relevant technologies, by protecting and licensing our intellectual properties, and by contributing to the U. S. economic security and quality of life. The following paragraphs provide an overview highlighting the Department's accomplishments in FY 2002.

Center Team Members Receive Federal Laboratory Consortium Honors

Three MSFC team members were awarded the Federal Laboratory Consortium's Excellence in Technology Transfer Award in 2002 for the computer-based Video Image Stabilization and Registration (VISAR) system. This system can make clearer minute details in blurred or poor quality video. The technology has received praise for its use as an aid to law enforcement.

New Incentive Program for MSFC Employees Initiated—Innovators Recognized for Their Contributions

The Technology Transfer Department initiated a new incentive program in FY 2002 to recognize the contributions of MSFC innovators. The New Technology Reporting (NTR) award is given to employees who submit their innovations through the formal disclosure process. In this initial year for the NTR Award, 149 employees representing every department at the Center were recognized.

Technology Awards Presented—Employees Rewarded for Technology Contributions

The success of the Technology Transfer Department depends on the support of everyone at the Center. In FY 2002, 11 employees and contractors were recognized for their special contributions to the technology transfer program. These monetary awards were presented by the NASA Associate Administrator and the MSFC Director at the annual awards ceremony on July 30.

New Technology Reporting—Capturing and Sharing Leading-Edge Technologies

One of NASA's primary goals is to share leading-edge technology with the U.S. industrial community. The new technology reporting process provides an avenue for inventors to disclose their inventions, discoveries, and innovations. In FY 2002, 187 new technologies were reported and assessed for commercial potential, with over $80,000 in incentive awards distributed to MSFC civil service and contractor inventors.

Technology Commercialization and Licensing—The Catalyst Uniting Technologies With Commercial Applications

MSFC's Technology Transfer Department works to facilitate the patenting and licensing of MSFC-owned technologies and innovations, ensuring that their maximum commercial potential is realized. During FY 2002, MSFC filed 25 patent applications—resulting in the issuance of 22 patents—and entered into four new licensing agreements. Royalty income for the fiscal year was over $89,000, bringing the cumulative total in royalties earned by the Center to well over

The STS–110 mission prepared the *ISS* for future spacewalks by installing and outfitting the S-Zero Truss and the Mobile Transporter.

$275,000. Through this licensing process, technologies developed by the Center are used by industry to impact the commercial market and advance the economy of those companies and the Nation as a whole. In FY 2002, Intergraph Corporation sold 23 Video Analyst systems based on the VISAR technology developed at the Center; Concepts NREC incorporated the MSFC-developed Generalized Fluid Systems Simulation Program software into their Turbine Airfoil Agile Design System, which should be on the market in 2003; two companies have sold seven complex, innovative machines using the MSFC-designed Retractable Pin Tool; and three companies are incorporating the innovative MSFC-developed High-Strength, Wear-Resistant Aluminum Alloy into their engine designs.

Software Commercialization and Licensing—Software Releases Maximize Benefits to the Nation

NASA-developed software is commercialized and licensed through Software Usage Agreements. These agreements ensure the software's release in a way that provides maximum benefit to the national economy. FY 2002 again saw MSFC set a new record in the award of 271 software usage agreements, bringing the cumulative number of such agreements to 809.

Small Business Programs—Leveraging America's Entrepreneurial Resources

The goal of NASA small business programs—the SBIR and STTR programs—is to strengthen the role of small businesses in meeting federal technology needs.

In FY 2002, 78 SBIR Phases I and II contracts were awarded with a total value of almost $25 million. There was also one STTR contract awarded valued at $0.5 million. In addition, 34 SBIR Phase III contracts were active in FY 2002 with a value of more than $19 million. Phase I awards are presented to determine the scientific and technical merit and feasibility of an innovation; Phase II awards are for the continuation of development of those innovations shown to be feasible in Phase I; and, finally, Phase III covers those activities capitalized by non-SBIR sources of funding for the pursuit of private sector or government sales.

Minority and Woman-Owned Business Initiative—Providing Opportunities to This Vibrant Segment of Our Nation's Economy

The Minority and Woman Owned Business (MOB/WOB) Initiative is designed to promote technology development and deployment collaboration between NASA and these targeted technology based companies. MOB/WOB expositions help celebrate the diversity, innovation, and imagination that these small businesses bring by introducing them to the NASA technical community. In addition, as MSFC's Small Business Technical Advisor, Technology Transfer coordinates with the MSFC Procurement Office to review the technical content of procurement documents with an eye towards bringing the capabilities of this segment of our Nation's economy to bear on meeting the needs of our space program. In FY 2002, two expositions were held to target MOB/WOB businesses with technology expertise, providing a forum for them to present their capabilities, network with similar companies, and explore teaming opportunities to strengthen their business bases. Two hundred eighty-four executives from large and small businesses, as well as representatives from NASA management and procurement, were brought together at these expos held at Calhoun Community College and Alabama A&M University.

Workshops Provided to Regional Small Businesses—Guidance Offered to Assist Small Businesses Secure NASA Funding

Each year NASA awards thousands of dollars to small, high-tech companies and research institutions to perform research and development in key technology areas through the SBIR and STTR programs. To increase awareness of the opportunities afforded by the SBIR and STTR programs, MSFC's Technology Transfer Department participated in 12 small business workshops throughout Alabama, Tennessee, and Georgia in FY 2002. These workshops were coordinated by such organizations as the Southeast Regional Technology Transfer Center at Georgia Tech, Huntsville's Business Technology Development Center, the office of Tennessee Congressman Bart Gordon, and the City of Chattanooga. The workshops offered advice on how to write winning proposals, offered detailed regional resources available to small businesses, and featured input from currently successful SBIR companies.

Technology Development and Deployment Partnerships—Ingenuity at Work

MSFC's Technology Transfer Department is discovering novel solutions for filling the technology needs of NASA, while supplying NASA ingenuity in ways that help America grow, through partnership opportunities with industry, small business, academia, and other government entities.

The department also works to create partnerships through which educational and commercial partners may use MSFC facilities for a fee. There were 124 agreements active in FY 2002, of which 45 were new agreements. These active agreements had a total value in FY 2002 of over $7.6 million.

Facilities Commercialization—Opening the Doors for Success

The MSFC has numerous unique scientific facilities and laboratories that are made available on a noninterference basis to educational and commercial partners under a cost reimbursement arrangement. The commercialization of these facilities is mutually beneficial for the partner and the Center. In FY 2002, an agreement was executed whereby a major aerospace manufacturer leased office and manufacturing space for a term of 5 years. Over the life of the agreement, MSFC will realize a return of over $1 million.

Center Director's Discretionary Fund—Promoting Innovation in the Workforce

The CDDF provides funding opportunities for well-defined research or technology development projects in scientific or technical areas. The projects are required to be innovative and support new ideas or concepts relevant to current or planned NASA programs, and must be aligned with MSFC's roles and missions and clearly contribute to the core competencies of the technical workforce.

The projects largely are performed in-house, involving outside groups or contractors only to the extent necessary. An important CDDF objective is to cultivate MSFC talent through hands-on experience. During FY 2002, 36 new projects were initiated and 21 former projects were continued with a combined expenditure of almost $2.3 million.

Technology Investment Program—Providing Seed Money to Advance Commercialization Efforts

The MSFC TIP is funded and managed by MSFC's Technology Transfer Department to underwrite high-risk technologies that support established NASA goals and objectives while also exhibiting high commercial potential. These technologies typically require an infusion of resources to increase their potential for commercialization. The program works in conjunction with the Center's patenting and technology commercialization efforts, and maximizes the opportunities for commercial success of MSFC-developed innovations. A recent success story realized through this program was the patenting, licensing, and commercialization of the VISAR software.

Projects selected for funding must be limited to in-house work, must have been formally disclosed, must demonstrate a high probability of commercial success, must be aligned with the roles and mission of the Center, and must be of one year duration or less. In FY 2002, $1.4 million was provided to MSFC product line organizations in support of 23 new projects.

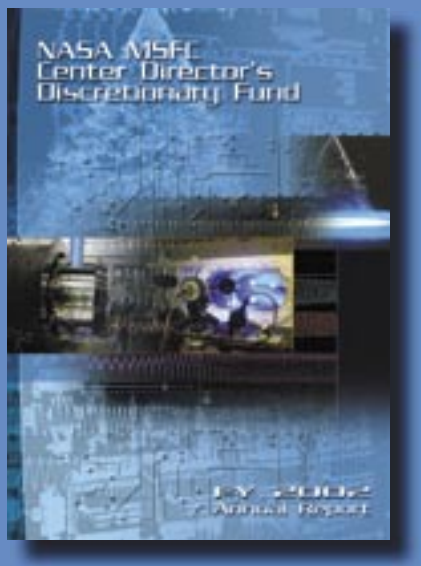
A companion program to TIP is the Commercial Investment Program, which is designed to provide Technology Transfer funds in support of local, regional, and state-level collaborations that have strategic value to NASA's mission and economic development of our region. One hundred thousand dollars in such funds were awarded to four projects during FY 2002.

Metrics

FY 2002 Institutional Products and Services Metrics

Increase the number of new partnerships that compliment MSFC's primary mission areas and that leverage the limited resources available to the Center; increase the number of new licensing agreements that provide monetary value to the Center and its innovators; increase the number of new success stories that highlight the technologies of MSFC.

In FY 2002, the MSFC Technology Transfer Office established 45 new partnerships, as compared to 38 such partnerships in FY 2001; entered into four new licensing agreements as compared to no such agreements in FY 2001; and released 18 new success stories related to MSFC technology development as compared to 16 such releases in FY 2001.



Center Operations Directorate

The Center Operations Directorate provides essential support services in numerous functional areas, which enables our customers to achieve Mission success. Our contribution ensures that Marshall Space Flight Center (MSFC)'s work in research, development, and technology yields the greatest value to NASA and, ultimately, the American people. Specific service categories include:

- Integrated Financial Management Project Office
- Environmental Engineering
- Facilities Engineering
- Office of the Chief Information Officer
- Logistics Services
- Protective Services
- Integrated Customer Support
- Center Industrial Labor Relations
- Medical Services

In addition, we serve in an advisory capacity to the Center Director and work in partnership with our customers to understand and fulfill their needs. We make decisions reflective of the Center's values of People, Teamwork, Customers, Innovation, and Excellence.

Special Events

MSFC sponsored approximately 220 special events during FY 2002. Annual events supported included the Moonbuggy competition, Retiree Dinner, Centerwide picnic, Earth Day, and Safety Day. Center Operations provides a variety of support functions for these events including: Coordination, moves, facilities, information technology, graphics, and security.

Students from across the United States and as far away as Puerto Rico and South America came to Huntsville, Alabama for the 9th annual Great Moonbuggy Race at the U.S. Space Rocket Center. Center Operations provided Special Event Coordination as well as television, digital imaging, audio visual, and graphics support for this event.

Home Security Awareness

In an effort to extend employee safety and security from the workplace to the home, MSFC Center Operations conducted Home Security presentations for personnel throughout the Center, to emphasize IT security awareness and protection for our employees outside the workplace.

Property Accountability

Major improvements in property management processes were realized in FY 2002. Lost property rates were reduced dramatically due to reengineered and improved processes. Joint inventories were conducted that allowed partnering with Center contractors. A Centerwide Property Awareness Campaign was held in FY 2002 and continues to provide MSFC an accurate property accountability program.

MSFC Just-in-time Desktop Administrative Supply System

Center Operations continues to improve the Centerwide program for the new Web-based ordering systems to purchase office supplies by adding other supply commodities. The system allows representatives from each organization to electronically order supplies for next-day delivery to the requestor's desktop. This system created efficiencies by eliminating the need for storage of large volumes of supplies and allowed for the closure of the Center's office supply annex. The entire Center began using the system in FY 2001. Since initiation, the Just-in-time (JIT) program has continued to grow in popularity, averaging more than 1,000 orders per month.

Disposal Operations

During FY 2002, the Disposal Operations continued its sales partnership with the General Services Administration, and conducted its first Internet Sale of Government property with proceeds from all sales of $277,337. The disposal team, consisting of contractor and civil service employees, processed over 10,000 items of equipment. The team was instrumental in facilitating the transfer of 26,000 pounds of mahogany, residual tooling from the X–34 program, to the Vermont State Agency for Surplus Property to the Lake Champlain Maritime Museum to be utilized on the Burlington Schooner Project. The team transferred 114 items valued at $1,878,145 to other Federal and State agencies and donated 287 items valued at $778,539 to schools in the southern region surrounding MSFC.

Critical Hardware Moves

In FY 2002, the MSFC Center Operations Directorate supported moves of program critical hardware (PCH). These moves included onsite as well as offsite moves via the NASA Super Guppy. The *ISS* oversized hardware included the S5 Truss Flight Article, S6 Integrated Equipment Assembly Truss Flight Article, the Node Structural Test Article, and Common Module. Also, some smaller components were moved onsite for the *ISS* Regenerative ECLSS Water Processor Assembly, Power Supply Module, and the Oxygen Generator Assembly. Provided PCH support in preparing the setup of the Toxicity Chamber to perform thermo test to Urine Processor Assembly. Provided unique receipt and delivery support to the Solid Rocket Booster program for

A section of the *ISS* truss assembly arrived at the Marshall Space Flight Center on NASA's Super Guppy cargo plane for structural and design testing as well as installation of critical flight hardware.

the qualification testing performed at MSFC of more than 20 Forward and Aft Bolt Housings. Analysis was also performed to determine the best mode of transportation to support the requirements to transport the GP–B satellite from Sunnyvale, CA, to Vandenberg Air Force Base for launch on a Delta II rocket. The Logistics Engineering Group is leading the design, assembly, and operations task for GP–B with a delivery and launch in FY 2003.

Pollution Prevention

CY 2002 brought a reassessment of the MSFC Pollution Prevention (P2) Program. In accordance with Executive Order 13148, MSFC developed and published a new P2 Plan establishing new P2 goals and assessing new P2 opportunities.

As part of the planning and efforts to establish JIT chemical procurements to reduce onsite chemical inventory, MSFC personnel visited NASA's Jet Propulsion Laboratory to benchmark their JIT chemical procurement system. Groundwork was laid in the new logistics contract to firmly establish JIT chemical procurement at MSFC beginning in 2003.

MSFC replaced five part cleaners at the Vehicle Maintenance Shop with three recycling systems. These systems recycle the spent solvent and reduce waste disposal. This project eliminated 4,500 pounds of waste generated annually and saved $300 annually on service fees.

MSFC implemented a reverse osmosis system to manufacture deionized water for plating operations. This new system eliminated 6,000 gallons annual usage of sulfuric acid and sodium hydroxide, and reduced costly spill response activities and storm water compliance issues.

Through outsourcing and/or process changes at the Plating Shop, MSFC eliminated several chromium processes. This resulted in reductions of 7,852 pounds of chromium usage and 9,920 pounds of perchloroethylene usage by converting to aqueous degreasers.

Environmental Assessments

During FY 2002, the MSFC Environmental Engineering Department continued to ensure the necessary requirements of the National Environmental Policy Act were implemented on programs such as the SLI Program and Construction Projects.

Environmental Management Systems

As required by Executive Order 13148 and NPG 8553.1 NASA's Environmental Management Systems (EMS), the MSFC Environmental Engineering Department is developing an EMS. This is a system that (1) incorporates people, procedures, and work practices in a formal structure to ensure that the important environmental impacts of the organization are identified and addressed, (2) promotes continual improvement

by periodically evaluating environmental performance, (3) involves all members of the organization as appropriate, and (4) actively involves Senior Management in support of the environmental management program. The Executive Order requires Federal Facilities to implement an EMS by 2005. The MSFC EMS is to be implemented by the end of FY 2003.

Superfund Cleanup

Under the Comprehensive Environmental Response Compensation and Liability Act program at MSFC, the characterization and investigation of the groundwater and methods of remediating groundwater contamination increased the understanding of contaminate transport and effective technologies for cleaning groundwater. Pilot tests of two candidate remediation technologies were tested at two contamination source areas. The results from these tests will be combined with other tests to determine a sitewide strategy.

Evaluation of potential perchlorate use at MSFC was conducted and submitted to regulatory agencies. Both the Environmental Protection Agency (EPA) and the Alabama Deparment of Environmental Management approved the report.

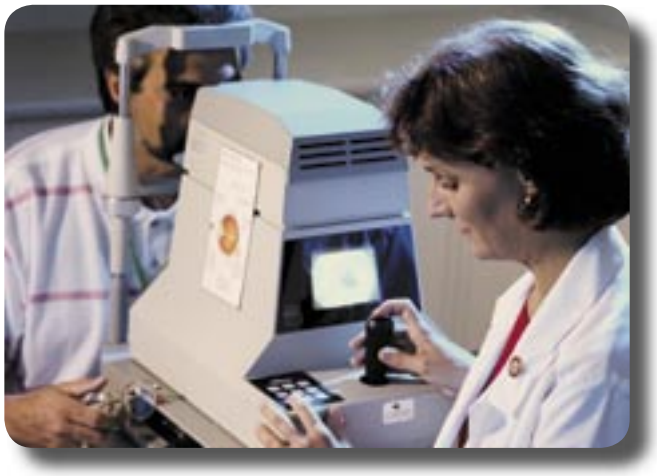
The paper was again presented at the North Atlantic Treaty Organization (NATO) conference in Rome, Italy, in May 2002; at the NASA Annual Environmental Conference in Norfolk, VA, March 2002; and at the Battelle Third International Conference on the Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, May 2002. The paper has been featured as a NASA press release, "Pollution Solution," April 2002; in EPA Technology News & Trends, July 2002; and submitted to Remediation Journal for publication in the spring issue. The MSFC Environmental Engineering Department author has been featured in the Who's Who at NASA—NASA Tech Briefs, September 2002—and spoken to the Huntsville Branch of the American Society of Civil Engineers in April 2002.

Onsite Medical Services

To support a safe and healthy work environment, MSFC civil service personnel and onsite contractors were provided access, as dictated by the parameters of their jobs, to physical examinations, special screenings, immunizations, first aid, and emergency assistance. During FY 2002, approximately 11,600 patients received services at the MSFC Medical Center.

FY2002 Construction of Facility Program

Funding was provided for three discrete institutional Construction of Facility projects totaling $7.5 million, all of which were awarded in the first quarter. This again met a very challenging metric established by NASA HQ reflecting the dedication and hard work of the Facilities Engineering Department and Construction Group. In addition, close management of the overall program resulted in an almost certain opportunity for the Center to receive approval and an additional $2 million of funding for the construction of a new Child Development Facility.



Nurse performs tonometry examination, which measure the tension of the eyeball, during an employee's annual physical examination given by MSFC Occupational Medicine Environmental Health Services under the Center Operations Directorate.

Propulsion Research Laboratory

The design for the new Propulsion Research Laboratory project was completed, and the contract for construction was awarded in June 2002. The facility construction is well underway with a projected completion date of April 2004.

Replacement Building 4600

Replacement Building 4600 is a new office building to replace miscellaneous office/laboratory buildings at MSFC that are currently scheduled or being considered for demolition. The project design started in May 2002 and is scheduled for completion in January 2003. The construction will be phased-funded over two fiscal years (FY 2003 and FY 2004) and is scheduled to begin in May 2003.

New Multipurpose Activity Building 4316

A design and construction of a new 15,700-square-foot building was completed in November 2002. This building will accommodate up to 800 people and provides a suitable place for special events, meetings, and other activities for the Center.

New Wellness Center 4315

The construction of the Wellness Center was completed in January 2002. This facility serves to improve the health and well being of the MSFC team, both civil servants and contractors.

New Facilities Master Plan

A new facilities master plan is in the approval process and will provide a detailed framework for many aspects of facilities planning for the next 20 years. The master plan will take into account the significant mission shifts that have occurred at MSFC over the past few years. The focus of the plan will be land-use zoning, potential facility locations, campus development, transportation, and facility standards. The new plan is scheduled for completion in late summer 2003.

Information Technology Security

Significant progress was made by the MSFC Information Technology (IT) Program, supporting elements, and MSFC organizations during FY 2002 in all areas of the Center's IT Security posture, including program and policy development, training, risk management, engineering, and operations.

The NASA Office of the Chief Information Officer conducted, with IT security at MSFC, a peer review inspection and discussion of the MSFC IT Security Program and its related activities, to increase sharing of best practices and program improvements among Agency Installations' computer security programs.

During FY 2002, MSFC reduced the number of key security vulnerabilities and weaknesses in the Center's computer systems, and reduced the number of MSFC computer system security compromises, in the face of significant increases in security intrusions experienced across U.S. corporations, industry, and academic institutions.

MSFC cosponsored, with U.S. Army Aviation & Missile Command, the two-day Information Security and Awareness Conference and Exposition at the Redstone Arsenal Sparkman Center auditorium. This event was offered to MSFC employees and contractor personnel in order to increase awareness of computer security issues and solutions.

Metrics

FY 2002 Center Operations Directorate Metrics

Ninety percent customer satisfaction in FY 2002.

NACC provided highly available—99.9 percent—and cost-effective mainframe computing systems for 15 different Agency workloads during FY 2001. The NACC has a customer satisfaction goal of 95 percent. For FY 2001, the satisfaction percentage averaged 96 percent.

In FY 2002, the Logistics Services Department met and surpassed the goal of ninety percent customer satisfaction. The department's performance was measured by analyzing the results of our customer survey—MSFC Form 4362. The survey identified a customer satisfaction rating of 4.88 (97.6 percent) out of a perfect 5.0 (100 percent) rating. Measurement criteria are timeliness, courteousness, knowledge, quality, meeting needs, and safety.

After a Centerwide survey conducted in FY 2001 indicated a customer satisfaction rate of 96 percent, the Facilities Engineering Department, based on electronic customer feedback, is proud to have maintained that rate for FY 2002.

Minimum 90 percent availability for primary mission-related facilities.

The Facilities Engineering Department met the goal for availability of primary mission-related facilities in FY 2002.

Maintain a minimum 95 percent availability rate for all Information Technology services.

NACC provided highly available (99.99 percent) and cost-effective mainframe computing systems for 15 different Agency workloads during FY 2002. The NACC has a customer satisfaction goal of 95 percent. For FY 2002, the Customer satisfaction percentage averaged 97 percent.

Provide a multifaceted security education and awareness program.

Significant progress was made during FY 2002 in all areas of the Center's IT security posture, including program and policy development, training, risk management, engineering, and operations.

One hundred percent training was achieved during FY 2002 for general employee, manager, and IT system administration basic IT security awareness training, using a Web-based training format. This training helped to reemphasize essential computer security awareness and understanding.

MSFC cosponsored, with the Army, a two-day Information Security and Awareness Conference and Exposition. This event was offered to increase awareness of computer security issues and solutions in the workplace.

Facilities Master Plan.

A new facilities master plan is in the approval process and will provide a detailed framework for many aspects of facilities planning for the next 20 years. The master plan will take into account the significant mission shifts that have occurred at MSFC over the past few years. The focus of the plan will be land-use zoning, potential facility locations, campus development, transportation, and facility standards. The new plan is scheduled for completion in late summer 2003.

Make physical examinations, special screenings, immunizations, first-aid, and emergency assistance available to all employees.

All MSFC Civil service personnel were provided access to physical examinations, special screenings, immunizations, first aid, and emergency assistance during FY 2002. In addition, onsite contractors—as dictated by their jobs—received physical exams, special screenings, and immunizations. All contractors were provided access to emergency assistance services. During the last year, approximately 11,600 patients were seen for exams and clinical visits.

Environmental Health Services Building Inspections.

To support a healthier and safer workplace, Environmental Health Services performed 222 building inspections; 1,260 industrial hygiene surveys, which aided in identifying potential hazarous environments; 667 health physics activities in addition to supporting events associated with the Propulsion Research Center; and trained 2,770 MSFC personnel in various topics such as hearing conservation, confined space entries, blood-borne pathogens, hazard communication, respiratory protection, radiation, and laser safety. During FY 2002, approximately 300 ergonomic evaluations were performed and 1,300 asbestos activities conducted.

Reduce Noncompliance Incidents and Releases by five percent from the FY 2000 level by FY 2005.

MSFC continues to exceed this metric. The FY 2000 baseline is 35 incidents and releases, and for FY 2002 the Center experienced 23 incidents and releases. This results in a 34 percent reduction.

Establish an Environmental Liability Baseline, then reduce liability dollar for dollar by amount spent.

The baseline environmental liability (remediation) was established during FY 2002 and is being tracked. MSFC met this metric for FY 2002 and is on target to continue to meet this objective in the future.

Ninety percent services provided at competitive rates by FY 2002.

Information technology services offered at competitive rates during FY 2002 include applications programming support for both MSFC and the Agency; MSFC telephone and long distance services, cell phones, and pagers (outsourced); NACC mainframe and midrange computing support; and services provided by the Central Reproduction area. Logistics Services provides the Center with 21 services. Of the 21, 14 services can be compared to the commercial sector. Specialized services such as property support, mail, and program-critical hardware cannot be compared in a competitive market. Of the 14 services, 13 were competitive and travel services continue to be monitored to determine competitiveness. This is a 93 percent rating.

Perform annual building inspections and special inspections to ensure a healthy work environment.

Logistics Services Department Manager performed routine inspections of buildings occupied by Logistics Services employees and contractor employees, to identify and correct hazards. Recommended corrective actions to any safety findings are tracked from initiation to closure.

Additional Center Operations Metrics.

An achievement level of 100 percent was recorded in FY 2002 for general employee, manager, and IT system administration basic IT security awareness training, using Agency-provided Web-based instructional materials, to help establish and update a known baseline of essential computer security awareness and understanding.

Customer and Employee Relations Directorate

Technology Transfer Department

MSFC's Technology Transfer Department utilizes focused program areas designed to innovate, incubate, and accelerate technological advances—from conception, through development, demonstration, and commercial realization. It is a strategically focused program aimed at complementing the mission objectives of the Agency's enterprises and product lines while ensuring that NASA's scientific and technological advances help to sustain the competitiveness of U.S. industry. The Department strives to meet its objectives through three major strategic areas: Partnerships, Commercialization and Outreach.

During FY 2002, 45 new partnership agreements were finalized bringing the total of active agreements to 124. These agreements had a total FY 2002 value of over $7.6 million. In addition, 79 Small Business Innovation Research and Small Business Technology Transfer contracts were awarded in Phases I and II with a total value of over $25 million.

MSFC filed 25 patent applications in FY 2002 resulting in the issuance of 22 patents and entered into four new licensing agreements. Royalty income for the fiscal year from all active licenses was over $89,000. Additionally, FY 2002 again saw MSFC set a new record in the award of 271 software usage agreements bringing the cumulative number of such agreements to 809.

In the technical outreach area, presentations were made at 96 technical conferences and events, 27 articles were published in NASA Tech Briefs, 18 success stories were released to the public, and three articles highlighting MSFC technologies were published in national trade journals.

Media Relations Department

MSFC's Media Relations Department greatly exceeded its FY 2002 Implementation Plan metrics. The goal of conducting a national news media campaign each month during the year, for a total of 12, was almost tripled, as a total of 30 campaigns were conducted. During 2002, the department issued 336 news releases, fact sheets, and media advisories to more than 142,000 news organizations worldwide. Those releases and other news media contacts resulted in 2,435 known newspaper, magazine, television, Internet, and radio news stories in 49 states and the District of Columbia, reaching a total potential audience of more than 70 million readers, 99 million radio listeners, and 235 million television viewing households. The total dollar value of the print and television coverage is estimated to be more than $4.4 million. A total of 101 news releases dealt with minority subjects or were geared to minority audiences and resulted in stories reaching a potential audience of more than 13 million readers.

The metrics goal of directly communicating with 200,000 people nationwide at exhibit events was exceeded sevenfold as more than 1.5 million people experienced MSFC exhibits at 110 events throughout the nation. Sixteen of these were minority events attended by more than 164,000 people. Also, the department arranged for a variety of NASA hardware and information to be on display at 63 museums nationwide, available for viewing by some 15 million museum visitors. The Starship 2040 traveling trailer exhibit proved to be very popular and was seen by more than 620,000 people, three times as many as in 2001.

Government and Community Relations Department

The Government and Community Relations Department achieved its primary objectives in FY 2002. The objectives centered around the following areas: briefing key stakeholders including Members of Congress on MSFC's missions and programs, and increasing the Center Director's speaking opportunities and the speaking opportunities of other MSFC team members.

Each of these objectives contributed to the Government and Community Relations Department's goal—to promote the understanding of NASA's missions and the role MSFC plays in ensuring the overall success of the Agency.

The Government and Community Relations Department coordinated over 15 congressional briefings by the Center Director on the ISTP and NASA's overall budget. Also, a top-level Capitol Hill Forum was held for congressional staff on the ISTP. Over 30 congressional staff members attended the briefing.

Additionally, the Government and Community Relations Department held discussion forums with several aerospace industry groups on MSFC programs.

The MSFC's Speakers Bureau is part of the Government and Community Relations Department. During FY 2002, the Speakers Bureau booked 163 speaking engagements for 59 MSFC employees. Approximately 20,000 citizens were reached through the MSFC Speakers Bureau. Topics were presented from all of MSFC's main mission areas.

The Government and Community Relations Department processed 282 Freedom of Information Act requests for FY 2002. The median response time for these requests was 19 days, 1 day sooner than the 20 day required response time.

MSFC answered over 1,600 public inquiry requests for the FY 2002. Most inquiries were answered within 10 days of request.

The Government and Community Relations Department partnered with other Center organizations in leading the Center's Combined Federal Campaign Committee in raising $546,878 for the FY 2002 initiative.

The Government and Community Relations Department successfully partnered with the Huntsville/Madison County Chamber of Commerce and other community groups for the celebration of the Apollo 17 anniversary in December.

The Government and Community Relations Department coordinated the Director's Breakfast for community leaders and elected officials and the Center Director's luncheon with onsite contractors.

Internal Communications and Relations Department

The Internal Communications and Relations Department accomplished 100 percent of its Center-level metrics in FY 2002.

The Balanced Scorecard Web site was established and implemented to track and status MSFC Center metrics. During FY 2002, Center management and employees were able to track the Center's progress against 185 Center-level metrics, in real time.

FY 2002 marked the realization of the completion of the redesign/relocation of the MSFC Heritage Gallery to the main lobby of Building 4200. The redesigned Gallery is both functional and inspiring.

The reformatting of MSFC's weekly newspaper, the Marshall Star, was also completed in FY 2002, making the paper a more reader-friendly news publication.

Employee and Organization Development Department

In 2002, one of the metrics for the Employee and Organization Development Department (EODD) was to establish a disciplined approach for Center organization performance consulting.

To that end, EODD has developed a new Individual Development Plan (IDP) process. This new process will help to accomplish several things:

- Organizational goals, objectives, and strategies will be communicated to and understood by everyone.
- The skills and knowledge needed to accomplish these goals and objectives will be systematically identified by each organization.
- Existing skill gaps will be identified and documented.
- IDPs will be generated that reflect the needs of the organization as well as the aspirations of the individual.
- These IDPs will form the basis of the respective organizational training plans.

By using the IDP as one means of aligning the development of the individual with the needs of the organization, the work of the Training Consultant will:

- Focus more on performance and less on training.
- Be more proactive, less reactive.
- Follow a structured, disciplined approach to helping the organizations identify and plan for the development of employees.
- Evolve toward an active partnership with management, where the Training Consultant is recognized as a valuable resource in improving all aspects of organizational performance.

Education Programs Department

The Education Programs Department manages a variety of programs that, during FY 2002, impacted more than 29,784 students and 22,604 teachers and faculty representing all 50 states. The Education Programs Department recorded 427 incidents of education partnerships and collaborations with other Federal, State, and local programs, professional societies, nonprofit organizations, industry and contractor communities, and all levels, but primarily K–12, of the educational community. MSFC employees and retirees volunteered to participate in the NASA Project Learning About Science, Engineering and Research (LASER) Program, serving locally as speakers, tutors, consultants, and science fair judges. MSFC's Educa-tor Resource Center (ERC), which is located at the U. S. Space & Rocket Center, conducted 136 teacher workshops for 1,326 educators. The ERC staff also provided 84,320 educational publications to 6,895 educators who visited or wrote to the facility. MSFC donated $884,284 in research equipment and placed some $211 million on grants, contracts, and cooperative agreements through education programs. During FY 2002, the NASA Vision and Mission Statements were revised, with education assuming a prominent role "To inspire the next generation of explorers." The Education Programs Department is refocusing MSFC's efforts to support NASA's strategic educational goals and objectives to inspire our youth and provide educators with the tools they need to teach math and science.

Metrics

FY 2002 Internal Communications and Relations Metrics

Establish and implement a Balanced Scorecard Web site to track and status all MSFC Center metrics.

The Balanced Scorecard Web site was established and implemented to track and status MSFC Center metrics. During FY 2002, Center management and employees were able to track the Center's progress against 185 Center-level metrics, in real time.

Complete the redesign/location of the Heritage Gallery to building 4200.

FY 2002 marked the realization of the completion of the redesign/relocation of the MSFC Heritage Gallery to the main lobby of Building 4200. The redesigned Gallery is both functional and inspiring.

Reformat the layout of the Marshall Star to create a more reader-friendly news publication.

The reformatting of MSFC's weekly newspaper, the Marshall Star, was also completed in FY 2002, making the paper a more reader-friendly news publication.

FY 2002 Education Programs Department Metrics

Establish a partnership with the Iowa Mathematics and Science Education Coalition to support the Iowa NASA Linking Leaders Initiative that will be patterned after the successful Alabama Linking Leaders model. NASA Linking Leaders Initiative are intended to provide leadership in improving mathematics, science, and technology education through the facilitation of communication among education, business, and public policy sectors.

A partnership has been established with the Iowa Mathematics and Science Education Coalition. Representatives of the MSFC Education Programs Department attended an initial meeting in November 2001. This partnership is an ongoing venture that will continue for the foreseeable future.

Increase the NASA Student Involvement Program (NSIP) participation in the MSFC six-stage geographical service region by 10 percent from the previous year.

The number of NSIP entries in the MSFC six-state geographical service region (Alabama, Arkansas, Iowa, Louisiana, Missouri, and Tennessee) for FY 2001 was 49. The number of entries for FY 2002 was 55, a 12% increase over the FY 2001 total.

Increase the number of student participants in our summer undergraduate research program by 10 percent from the previous year.

The Undergraduate Student Research Program (USRP) served 25 students in FY 2001. During FY 2002, the USRP program hosted 30 students, an increase of 20 percent.

NASA seeks to be judged by its customer—the education community—as providing excellent and valuable educational programs and services. Therefore, we will attempt to maintain an average excellence rating ranging between 4.0 and 5.0 (on a 5.0 scale), as rated by our customers.

During FY 2002, The overall excellence rating by our customers was 4.62, as measured on a 5.0 scale.

FY 2002 Human Resources Department Metrics

Maintain the level of civil service full-time employees (FTEs) to adequately support Center missions while maintaining diversity in the Center's workforce, subject to NASA Headquarters authority.

The MSFC received authorization to hire 51 FTE and 11 Cooperative Students during 2002. Minority hiring increased from 14 percent to 16 percent in 2002, while female hiring increased from 24.8 percent in 2001 to 31.4 percent in 2002.

Achieve greater automation of human resources processes pending sufficient funding from NASA Headquarters and timely software delivery by the vendor.

Position Description Management (PDM), part of the Integrated Financial Management Program, went live at MSFC on August 5, 2002. PDM automates the position description writing process, reducing the time the human resources staff, as well as supervisors and managers, need to create and classify position descriptions, allowing more time to work on other mission related activities.

Other Staff Offices — Equal Opportunity

Goal

Promote and strive for equal opportunity, equity, and diversity in all occupational groups, grade levels, organizational units, MSFC programs and activities, and fully accessible facilities. Conduct educational programs with historically black and other minority universities.

Metrics

FY 2002 Equal Opportunity Metrics

Increase workforce representation by 5 percent in underrepresented categories as defined in the Center's current Affirmative Employment Plan, provided MSFC receives hiring authority and a diverse pool of applications is available.

A total of 51 employees were added to the MSFC workforce in FY 2002. Of that total, 16 were white females, 6 Black, 1 Asian, and 1 American Indian. The Center continues to be underrepresented in some categories.

Improve the accessibility features in five of the Center's buildings and public access areas.

As individuals with disabilities are brought into the MSFC workforce or have specific needs, reasonable accommodations are provided. The accommodations for FY 2002 included:

- Construction modifications to improve accessibility in buildings 4727, 4487, and 4249 have been completed.
- Design for Building 4200 front entrance handicap ramp and renovation for tenth floor restroom have been completed. Construction will begin in the near future.
- Handicap parking spaces have been modified at various buildings across the Center.

Increase research participation with historically black and other minority universities by five percent, provided appropriate Agency resources are available for FY 2002.

- In April 2002, MSFC signed a Memorandum of Understanding with Tuskegee University to increase research opportunities with that institution.
- In FY 2002 summer, the pilot program for Preservice Teacher Institute was held jointly with NASA/Oakwood College. This new joint venture will continue to be funded in FY 2003.
- Funding for minority institutions managed by MSFC remained constant due to funding constraints.

Establish a customer feedback link on the Equal Opportunity Office Web site.

A customer feedback link was established on the Equal Opportunity Office Web site in FY 2002.

Office of Chief Financial Officer

Goal

Serve as stewards of Government resources. Develop and maintain processes and systems that ensure accurate financial control and accountability across the Center.

Metrics

FY 2002 Office of Chief Financial Officer Metrics

Obligate 95 percent of authorized funding for the current program year.

MSFC obligations were 97 percent in FY 2002.

Cost 70 percent or more of the resources authority available to cost within the fiscal year.

MSFC cost was 84 percent in FY 2002.

Implement the Integrated Financial Management (IFM) Core Financial System at MSFC by September 2002.

The IFM Core Financial Project completed implementation following the September 2002 fiscal year close. System stabilization is ongoing, including increased understanding of the new system and processes.

Establish an Earned-value Management (EVM) System for Space Launch Initiative (SLI) projects.

Principal Center for EVM has worked with the SLI projects to ensure EVM is properly implemented on all SLI contracts. In addition, appropriate training and support for Integrated Baseline Reviews has been provided to the SLI project. EVM data is currently being reported to SLI management for their review and management use.

Provide formal EVM process training through AdminSTAR.

EVM training for EVM basics and conducting Integrated Baseline Reviews was developed and taught to over 100 MSFC civil servant and contractor personnel during FY 2002, both through AdminSTAR and on an as-needed basis to the projects.

Office of Chief Counsel

Goal

Support MSFC's assigned roles and missions by providing sound, understandable, timely legal counsel, and legal representation of the highest quality to all MSFC organizational elements. Effectively administer the ethics program and the patent prosecution function for MSFC.

Metrics

FY 2002 Office of Chief Counsel Metrics

Produce at least 20 patent applications based on NASA Inventions and Contributions Board metrics.

The Office of Chief Counsel produced 22 patent applications in 2002.

Attain 80 percent positive assessment from our customers.

In 2002, the Office of Chief Counsel conducted feedback discussions with customer organizations that resulted in positive feedback that exceeded 80 percent.

Procurement

Goal

To provide highly effective and efficient acquisition and business support at the highest professional level to meet or exceed customer and stakeholder expectations. The Procurement Office seeks to improve the effectiveness and efficiency of Center acquisitions through increased use of techniques and management tools that enhance contractor innovations and performance.

Metrics

FY 2002 Procurement Metrics

Small business programs: Leveraging America's entrepreneurial resources.

Procurement supports the Small Business program objective of developing small business participation and to optimize utilization of America's full entrepreneurial resources. The small business staff supported this objective by accepting approximately 400 onsite business visits, 3,700 telephone information contacts, and participating in nine outreach events. The Center also has received NASA's unprecedented recognition for meeting all of its socioeconomic goals for four consecutive years. The performance against the small business implementation goals were 21.9 percent against a 20 percent small business goal and 10 percent against an eight percent small disadvantaged business goal.

MSFC continues it's emphasis on socioeconomic initative, but is giving new focus on the Historical Black Colleges and Universities initiative to increase participation to one percent of contracting dollars. Small business is also participating in specific focus outreach efforts aimed at providing assistance to machining and fabricating companies. An outsourcing team was established to support these activities by providing assistance to small businesses in understanding the ISO process, MSFC's marketplace, and how small businesses can have their capabilities displayed on MSFC's Audited Vendor List. In FY 2002, approximately 25 businesses were visited.

Increase obligated funds available for performance-based contracts to 80 percent.

MSFC achieved 91 percent for performance-based contracts in FY 2002. Through the utilization of performance-based contracts, the contractor is informed as to what is required versus how to achieve the required product. Use of this type of contracting, which is NASA's preferred method of contracting, clearly defines the requirement, provides a performance standard, provides a method of surveillance, weighs each element of the task, and provides for a reward/penalty system for the quality of work provided.

Systems Management Office

Metrics

FY 2002 Systems Management Office Metrics

Provide independent cost/economic assessments of 100 percent of Program Management Council (PMC) reviewed formulation phase projects above $100 million.

There were no program/project formulation requests for $100 million presented to the PMC. However, the Systems Management Office Cost Engineering Office has continued to provide cost/economic assessments in support of numerous MSFC program/projects. The Space Launch Initiative, Nuclear Space Initiative, and the Shuttle Upgrades Programs have been provided cost assessments to assist in programmatic formulation during FY 2002.

Revise NASA/Air Force Cost Model (NAFCOM) cost model every 18 months to include the latest cost data and model enhancements.

The NAFCOM 2002 edition was released April 2002. This release included additional mission data, improved capabilities, and features.

Expand Resource Data Storage and Retrieval (REDSTAR) database by five percent.

The REDSTAR database has increased by over 1,100 documents, reflecting a five percent increase for 2002.

Conduct independent evaluations —e.g., independent assessment, independent annual reviews, non-advocated reviews—of at least six MSFC projects.

All project requests for independent reviews were met for FY 2002. Seven independent cost assessments were completed by VS20, and two independent annual reviews were conducted by VS10.

Conduct one Center Export Representative (CER) training course.

Two CER training courses were held at MSFC in FY 2002. Over 150 employees were provided in-depth Export Control training. In addition, eight Export Control subject-specific courses were conducted.

Assess the level of satisfaction of all customers supported.

An informal assessment of selected customers is being conducted. The formal assessment was conducted in September, near the end of reporting year. The survey was completed and final results are posted on the Customer Satisfaction Web site.


NASA Solutions
Through America's Space Program, Dreams Become Reality
Technology Transfer
NASA

Outreach Activities

Sharing Our Story, Creating New Opportunities

An important part of the Technology Transfer Department's program is to inform the general public and potential customers about the ways that the MSFC and NASA serve the space community, American industry, and academia. The activities designed to provide this knowledge are grouped under the umbrella of Technology Outreach.

To meet these goals, Technology Outreach undertakes a variety of traditional and innovative activities to communicate its programs and present available technologies and opportunities. These activities include tradeshows, workshops, speaking engagements, a dynamic Web site, and publications highlighting technologies and opportunities for commercial transfer and partnerships. During FY 2002, presentations were made at 96 technical conferences/events and 27 articles highlighting MSFC technologies were published in NASA Tech Briefs. In addition, 18 new success stories were released to the public and three articles highlighting Compressed Symbology technologies were published in national trade journals.

As an integral part of the outreach activities, interactive multimedia display units are located in the Huntsville International Airport, the Birmingham International Airport, Madison Square Mall in Huntsville, and the MSFC Headquarters complex. These stand-alone, touch-screen units illustrate how the Space Program affects everyday life. They take viewers on a technology transfer journey that begins in the Apollo moon days and continues to evolve today. On average in FY 2002, the units recorded 11,849 hits per month.

NASA MSFC Boosts Alabama Economy With $897 Million in FY 2002 Expenditures

NASA's MSFC in Huntsville, AL, contributed $897 million to Alabama's economy in FY 2002.

Included were $273 million in salaries for civil service personnel and related costs, as well as travel. Also included was $624 million spent on locally procured services, prime contractor and subcontractor support, and local construction. The $897 million spent in Alabama was significantly more than MSFC's expenditures in any other state.

In addition, The Boeing Co. spent NASA funding of approximately $85 million in North Alabama for *ISS* hardware development. Approximately $45 million funding was spent by MSFC on NASA programs where MSFC had a supporting role, and an additional $9.5 million was spent on programs where MSFC performed work for other agencies.

MSFC received approximately 16.4 percent—$2.4 billion—of NASA's total budget of $14.9 billion during FY 2002. Of MSFC's budget, 57 percent was spent in support of Office of Space Flight for programs including Space Shuttle and Space Station activities, with 43 percent for Space Science, Earth Science, Aerospace Technology, Biological & Physical Research, and Crosscutting Technology Programs.

Since it was established in 1960, MSFC has had budget responsibility for more than $71 billion. When yearly figures are adjusted for inflation, this total is equivalent to more than $176 billion in today's dollar value.

Approximately $69 million in retirement annuities were paid in 2002 to 2,381 MSFC retirees residing in Alabama, with 1,619 retirees in Huntsville and Madison receiving $47 million of that amount.

Through September 2002, MSFC paid $5.4 billion in federal salaries since its creation in 1960. In 2002, MSFC civil service employees collectively paid about $32 million in Federal income taxes and about $7 million in Alabama state income taxes.

At the end of September, MSFC's permanent and temporary civil service employees totaled 2,713, including employees at resident offices at prime contractor facilities and at NASA's Michoud Assembly Facility near New Orleans, LA.

Of that workforce, 2,237 were college graduates, with 1,467 holding bachelor's degrees. There were 176 employees with doctorate degrees and 594 with master's degrees in fields of engineering and science, predominantly mathematics and physics, as well as other disciplines, predominantly business administration.

The Technology Transfer Department's multimedia displays present an array of space program benefit information to a wide variety of audiences. The content is updated as technologies are transferred, and gives a current snapshot of how some of the most promising NASA technical work is being applied to make life here on Earth better.

During 2002, 24,621 contractor personnel engaged in work for MSFC, including 3,264 in mission support, 10,696 on prime contract work, and 10,661 as subcontractors and vendors. Of the total, 6,730 worked in Alabama. Additionally, 396 contractors were associated with *ISS* work being done by Boeing in Huntsville and 652 jobs relating to other NASA work supported by MSFC.

During FY 2002, 57,700 people toured MSFC, including educators, conference and symposium visitors, and news media. In 2002, the attendance at the U.S. Space & Rocket Center in Huntsville was 332,214. The Space & Rocket Center is MSFC's official NASA Visitor Center.

During FY 2002, more than 29,784 students and 22,604 teachers and faculty representing all 50 states were reached through the operation of MSFC's education programs. MSFC donated $884,284 in research equipment and placed some $211 million on grants, contracts, and cooperative agreements through the education programs. MSFC recorded 427 incidents of education partnerships and collaborations with other Federal, state, and local programs, professional societies, nonprofit organizations, industry and contractor communities, and all levels, but primarily K–12, of the educational community. MSFC employees and retirees volunteered to participate in the NASA Project LASER Program, serving locally as speakers, tutors, consultants, and science fair judges. The NASA/MSFC Educator Resource Center (ERC), which is located at the U. S. Space & Rocket Center, conducted 136 teacher workshops for 1,326 educators. The ERC staff also provided 84,320 educational publications to 6,895 educators who visited or wrote to the facility.

Additional ways MSFC gives back to the community are through monthly Red Cross Blood Drives, where in 2002, 1,156 pints of blood were collected from civil service and onsite contractors. Also, MSFC civil service employees contributed $573,844 to the Combined Federal Campaign—$316,857 of the total was designated to help agencies in Alabama.

MSFC achieved 42 years of operation in 2002.

MSFC looks to the future with dedication to continue its role as a vital contributor to America's future in space while positively impacting local, state, and Federal economy.

Acronym List

ABACS	Automated Booster Assembly Checkout System
ACES	ALTUS Cumulus Electrification Study
AEE	Advanced Engineering Environment
AHMS	Advanced Health Management System
AMPET	Aerospace Materials, Processes, and Environmental Technologies
AMSD	Advanced Mirror System Demonstrator
AMSR–E	Advanced Microwave Sensing Radiometer for EOS
ARC	Ames Research Center
ASA	altitude switch assembly
ASI	Agenzia Spaziale Italiana
ASTP	Advanced Space Transportation Program
ATIC	Advanced Thin Ionization Calorimeter
AVGS	Advanced Video Guidance Sensor
AXP	anomalous x-ray pulsars
BPT	Build Process Teams
CAAS	Contract Administration and Audit Services
CBPA	Cryo-Biaxial Permeability Apparatus
CBSE	Center for Biophysical Science and Engineering
CCACS	Center for Commercial Application of Combustion in Space
CDR	Critical Design Review
CER	Center Export Representative
CFR	carbon fiber rope
COBRA	Co-optimized Booster for Reusable Applications
CORE	Central Operation of Resources for Educators
COSMIC	Combustion Synthesis under Microgravity Conditions
CS/CI	Customer Satisfaction and Continual Improvement
CSLM	Coarsening in Solid-Liquid Mixtures
CSOC	Consolidated Space Operations Contract
CSSI	Comprehensive Systems Skills Initiative
DART	Demonstration of Autonomous Rendezvous Technology
DCCO	Diffusion Coefficients in Crude Oil
DCPCG	Dynamically Controlled Protein Crystal Growth
DOD	Department of Defense
DOI	Department of Interior
ECLSS	Environmental Control and Life Support System
EDOP	enhanced diver-operated plug
EME	electromagnetic effects
EML	electrostatic levitation
EMS	Environmental Management System
ENSO	El Niño Southern Oscillation
EOS	Earth Observing System
EPA	Environmental Protection Agency
ESA	European Space Agency

ESIP	Earth Science Information Partner
ET	External Tank
EUSO	Extreme Universe Space Observatory
EVM	Earned-Value Management
EXPRESS	Expedite the Processing of Experiments to Space Station
FSW	friction stir welding
FTE	full-time employee
GA	genetic algorithm
GBM	GLAST Burst Monitor
GHCC	Global Hydrology and Climate Center
GHRC	Global Hydrology Resource Center
GLAST	Gamma-ray Large Area Space Telescope
g-LIMIT	Glovebox Integrated Microgravity Isolation Technology
GOES	Geostationary Operational Environmental Satellite
GP–B	Gravity Probe-B
GPS	global positioning system
GRB	gamma-ray burst
GRC	Glenn Research Center
GSFC	Goddard Space Flight center
GSTW	Global Science and Technology Week
GTE	ground test engine
HDTV	high-definition television
HIP	human interest protein
HMC–IRA	Health Management Computer-Integrated Rack Assembly
HPFTP	high-pressure fuel turbopump
HTCI	HEDS Technology Commercialization Initiative
HWMI	Hauptman-Woodward Medical Research Institute
IATR	Interim Architecture and Technology Review
IBC	Iterative Biological Crystallization
IEA	Integrated Electronics Assembly
IEC	Integrated Engineering Capability
IES	Integrated Engineering Solutions
IFA	in-flight anomaly
IFM	Integrated Financial Management
ISP	In-Space Propulsion
ISS	International Space Station
ISTAR	Integrated System Test of an Air-breathing Rocket
ISTP	Integrated Space Transportation Plan
JIT	just-in-time
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
JWST	James Webb Space Telescope
KSC	Kennedy Space Center
LaRC	Langley Research Center
LH_2	liquid hydrogen
LIS	lightning imaging sensor
LODESTARS	Levitation Observation of Dendrite Evolution in Steel Ternary Alloy Rapid Solidification
lox	liquid oxygen
LPAR	logical partition

LTIR	lost-time injury rate
MAF	Michoud Assembly Facility
MGM	Mechanics of Granular Materials
MnSOD	manganese superoxide disumutases
MOB	minority-owned business
MPE	Max-Planck-Institut für Extraterrestrische Physik
MPLM	Multipurpose Logistics Module
MRPO	Microgravity Research Program Office
MSAD	Microgravity Science and Development
MSFC	Marshall Space Flight Center
MSG	Microgravity Science Glovebox
MSL	Material Science Laboratory
MSRR	Materials Science Research Rack
MSU	microwave sounding unit
MUBLCOM	Multiple Path Beyond Line of Sight Communications
MXER	Momentum Exchange, Electrodynamic Reboost
NACC	NASA ADP Consolidation Center
NAFCOM	NASA/Air Force Cost Model
NANOSLAB	Study of Aggregation Mechanism and Kinetics of Nanoslabs Experiment
NATO	North Atlantic Treaty Organization
NCAM	National Center for Advanced Manufacturing
NEXT	NASA Evolutionary Xenon Thruster
NGLT	Next Generation Launch Technologies
NGST	Next Generation Space Telescope
NISB	NASA Institute of Structural Biology
NISN	NASA Integrated Services network
NMRT2	NASA Materials Replacement Technology Team
NMSD	New Mirror System Demonstrator
NOAA	National Oceanic and Atmospheric Administration
NRA	NASA Research Announcement
NSN	NASA Secure Network
NSTAR	NASA Solar Electric Propulsion Technology Application Readiness
NTR	New Technology Reporting
NWS	National Weather Service
OBPR	Office of Biological and Physical Research
OGS	Oxygen Generation System
ORR	Operational Readiness Review
OSP	Orbital Space Plane
P2	Pollution Prevention
PCAM	Protein Crystallization Apparatus for Microgravity
PDR	Preliminary Design Review
PFMI	Pore Formation and Mobility Investigation
PMC	Program Management Council
PRL	Propulsion Research Laboratory
PromISS	Protein Crystal Growth Monitoring by Digital Holographic Microscope
ProSEDS	Propulsive Small Expendable Deployer System
QMI	Quench Module Insert
R&D	research and development
RBCC	rocket-based combined cycle

RCE	Reaction Control Engine
REDSTAR	Resource Data Storage and Retrieval
ROSAT	Roentgen Satellite
RP	kerosene
RPC	Research Partnership Center
RSRM	Reusable Solid Rocket Motor
S&MA	Safety & Mission Assurance
SBIR	Small Business Innovation Research
SEA	Shuttle Environmental Assurance
SESC	Shuttle Engineering Support Center
SGR	soft gamma repeater
SHE	Safety, Health, and Environmental
SIO	Shuttle Integration Office
SIPS	Software Integrity, Productivity, and Security
SLI	Space Launch Initiative
SOD	superoxide disumutases
SOMTC	Space Optics Manufacturing Technology Center
SPD	Space Product Development
SPoRT	Short-term Prediction Research and Transition Center
SRB	Solid Rocket Booster
SRR	Systems Requirement Review
SSME	Space Shuttle Main Engine
SSMIS	Special Sensor Microwave Imager Sounder
SSP	Space Solar Power
SSPO	Space Shuttle Program Office
SRTM	Solid Rocket Test Motor
STTR	Small Business Technology Transfer
SUBSA	Solidification Using a Baffle in Sealed Ampoules
SUMI	Solar Ultraviolet Magnetograph Investigation
SXI	Solar X-ray Imager
TD	Transportation Directorate
THREADS	Technology for the Human/Robotic Exploration and Development of Space
TIMED	Thermosphere, Ionosphere, Mesosphere, Energetics, and Dynamics
TIP	Technology Investment Program
TPO	Turbine Performance Optimization
TRL	Technology Readiness Level
TRMM	Tropical Rainfall Measuring Mission
UAV	Unmanned Aerial Vehicles
USA	United Space Alliance
USAF	United States Air Force
USRA	Universities Space Research Association
VISAR	Video Image Stabilization and Registration
ViTS	Video Teleconferencing System
WCSAR	Wisconsin Center for Space Automation and Robotics
WOB	woman-owned business
WRS	Waste Recovery System
XRCF	X-ray Calibration Facility

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